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MICHELA'S STENOGRAPHIC REPORTING MACHINE.

THE stenographic reporting machine invented by M. Michela has received considerable attention in Europe, having been practically tested by the French Chamber of Deputies and Senate, and the Italian Parliament. This is not the first attempt of inventors to make a stenographic record by mechanical means. Many instruments and many systems have been successively tried and rejected. In 1867 a machine was constructed by M. Gensoul. But all of the attempts have failed up to this time on account of the difficulty of making the record on a band of paper of reasonable length. Gensoul's apparatus, for example, required more than a meter of paper to inscribe a phrase of a line and a half. The apparatus of M. Michela, presented to the Chamber of Deputies by M. de Bœmme, engineer, and operated by Mlle. Guillio, appears to have overcome this difficulty.

Upon an endless band of paper, which is unrolled automatically as the machine is operated, is impressed in relief and color at the same time the conventional prescribed symbols, which produce by their combination all of the sounds possible in human language. It is this arrangement which constitutes the proper character of the apparatus of M. Michela.

It must be understood that the operator is able, by the aid of his ten fingers, to execute almost simultaneously ten symbols, and he must have the advantage over the most practiced stenographer, whose hand is only able to trace one sign after the other.

FIG. 1.—PERSPECTIVE VIEW OF THE STENOGRAPHIC MACHINE OF M. MICHELA.

The imprinted lines of the stenographic band are traced regularly, distinctly, and neatly, avoiding what is called "bad writing." All of the symbols are as correct as letter-press.

A decimeter of the band will contain a phrase of relative length. In the Italian Parliament the band was cut every five minutes in order to be transferred. The record is read without difficulty, and five days is sufficient to master the instrument.

The experiment made in the Chamber of Deputies has given decisive results. M. Gambetta, President of the Chamber, and other officials assisted. Mlle. Guillio, who operated the machine, was an Italian, and spoke French very imperfectly. The experiment was commenced by a dictation in Italian, taken from the official journal of Italy. M. Michela read rapidly a discourse upon railways recently delivered in the Roman Senate. The dictation contained not less than a page, which Mlle. Guillio recorded and read without the least hesitation, as if she had the journal before her eyes.

In order to complete the experiment, the President of the Chamber requested M. Pierre, one of the recording secretaries, to read rapidly a page of official statements, and that the experiment might be as difficult as possible, the president made interruptions and motions in Latin. He began this himself and good-humoredly provoked interruptions among the auditors, which were faithfully recorded; but the curiosity of the assistants was so greatly excited that they did not think of interrupting.

"One may see that we are not in session," said M. Gambetta; "I have almost as much difficulty in pro

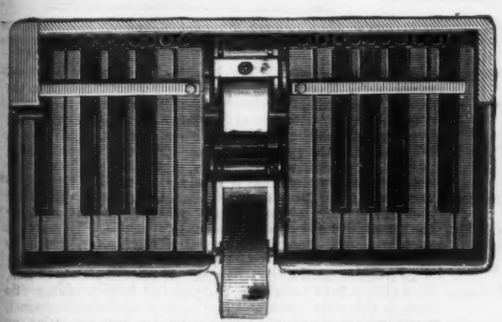


FIG. 2.—PLAN OF THE KEYBOARD OF THE APPARATUS.

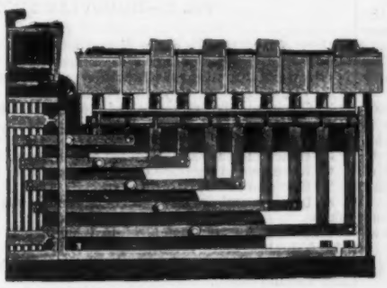


FIG. 3.—LONGITUDINAL SECTION OF THE KEYBOARD. (Right Side.)

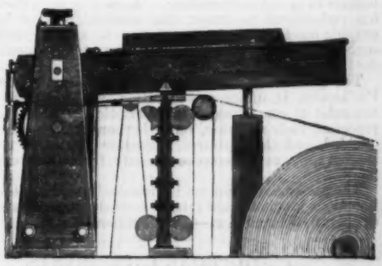


FIG. 4.—TRANSVERSE SECTION OF THE APPARATUS.

TRIAL OF THE STENOGRAPHIC REPORTING MACHINE, CHAMBER OF DEPUTIES, PARIS.

ducing interruptions now that I have ordinarily in preventing them."

Mlle. Guillio, who had understood very few of the words dictated to her, produced them, nevertheless, and transferred them with remarkable fidelity. Not being able to understand, she read badly, cutting the words into and forming the most eccentric words with the parts of the words; but the exactness of the record was not the less absolute.

The stenographic apparatus of M. Michela is shown in perspective in Fig. 1. It is inclosed in a small box, which is supported by three feet screwed to the base and easily detached.

Whatever may be the language to be recorded in shorthand, a series of sounds must always be resolved into syllables. If by a simple combination it is possible to inscribe exactly each syllabic phonation with the same rapidity that it is uttered, the problem of stenography is solved.

To accomplish this it is necessary that any syllable, whatever may be its complication, be inscribed by the stenographer at a single stroke. To do this the operator arranges his ten fingers upon a keyboard, identical with the keyboard of a piano, having white and black keys, and as each finger may act upon two keys without removing the hand, from one to ten symbols may be recorded with each hand. Each syllable uttered is recorded by the operator by the striking of a chord composed of a number of short-hand symbols, more or less varying between two and ten, and sometimes even of a single symbol for the syllables formed of a single vowel.

On account of the syllabic inscription, instead of the inscription letter by letter of former writing machines, it will be seen that the rapidity of the Michela apparatus is much greater; besides this the hands of the operator are never removed, and are always above the keys upon which they must act. The mechanical mode of inscription of these different chords corresponding to syllables will be easily comprehended by referring to Figs. 3 and 4, which represent sections of the apparatus.

The keys, as may be seen in Fig. 3, which represents the right side of the apparatus, act through levers upon a series of punches, arranged vertically in relation to a band of paper in the middle of the apparatus. The band unrolls in the direction of the length of the keys.

The levers raised by the keys apply the punches to the band of paper, and imprint upon it prescribed symbols which are distinguished either by their form or by their position upon the band of paper. The impression is made either dry or with ink. In the latter case an inking ribbon is used in connection with the punches. After each chord struck, the keys in rising act upon a small toothed wheel, and the feed advances one tooth. This wheel turns a roller, which carries the band of paper, thus insuring the inscribing of the syllables in regular succession.

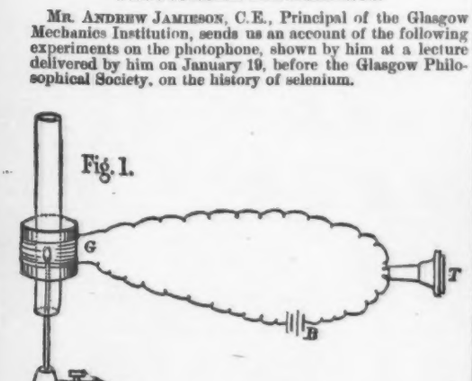
The reading is from left to right and from the top to the bottom as in ordinary reading. As may be seen, the inventor has endeavored to render the manipulation of his stenographic machine identical with that of a piano, and he has succeeded perfectly, as is proved by the experiment already described.

The question of introducing this machine in the French Parliament is under consideration. Orators have been in the habit of correcting the transcription of the stenographic report of their speeches, but it is thought that this may be avoided, and that printers, acquainted with this method of stenography, may compose directly from the stenographic bands.

The apparatus is not yet in practical use, but it is a very ingenious machine, and might be used with advantage in all deliberative assemblies.—*L'Illustration.*

PHOTOPHONE EXPERIMENTS.

MR. ANDREW JAMIESON, C.E., Principal of the Glasgow Mechanics Institution, sends us an account of the following experiments on the photophone, shown by him at a lecture delivered by him on January 19, before the Glasgow Philosophical Society, on the history of selenium.



The effects of light and heat on the conductivity of selenium were shown by means of a simple and inexpensive form of "cell" joined up in a Wheatstone's bridge with a reflecting galvanometer. The cell is constructed in the following way: A piece of plate glass or of a glass tube of about an inch diameter and about three inches long is chosen, and upon its exterior are tightly wound two separate parallel wires of No. 25 B. W. G., the wires themselves

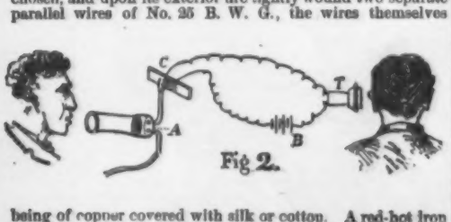


Fig. 2.

being of copper covered with silk or cotton. A red-hot iron or poker is then applied to the middle region of the coil of wire so as to burn off the insulating covering of silk or cotton. The bare wires are cleaned, and the blank cell being raised to the proper temperature, vitreous selenium is rubbed on the wires so as to fill the narrow interspaces left by the removal of the silk covering. The selenium is afterward annealed in the usual fashion to render it more highly conductive. One of the cells thus used had resistances of 5,740 and 3,440 ohms respectively in the dark and in the light; but others have less resistances, one being as small as 500 ohms in the dark. The first-named cell (a flat one) was twenty-one days old, and had increased several thousand ohms in that time.

The musical note of a "singing flame" was reproduced in the telephone by means of one of the annular cells thus formed upon a glass tube in the following manner, suggested by Prof. Blyth (Fig. 1). The cell, C, joined in circuit with a battery, B, and telephone, T, was placed outside, entirely surrounding the glass tube in which a small gas-jet was "singing." Speech was afterward reproduced by the arrangement shown in Fig. 2. At the back conical mouthpiece which receives the voice is fixed a membrane of goldbeater's skin, which forms the front of a chamber, A, into which gas is led, and from which a short tube leads to a small gas-jet, in the manner devised by König. Opposite the gas-flame was placed the selenium cell in circuit with a battery of twenty cells and a distant telephone. There were thus eleven changes going on simultaneously:

1. Muscular movement of speaker's vocal organs.
2. Vibration of air opposite speaker's mouth.
3. Corresponding vibrations of the thin membrane.
4. Variations of pressure controlling the supply of gas to jet.
5. Hence increase and decrease of gas-flame.
6. Increase and decrease of resistance of the selenium cell.
7. Rise and fall of battery current.
8. Increase and decrease of magnetism in magnet of telephone.
9. To-and-fro movement of telephone disk.
10. Vibration of air opposite the same.
11. Vibration of drum of ear of listener at the telephone and a sound heard.

Not only the pitch but the tone of the voice was distinctly heard.

ELECTRICAL TOTALIZING COUNTER.

APPARATUS serving to count automatically the number of revolutions of a rotary axle are frequently employed under a great number of circumstances that it would be of no interest to enumerate in this place, inasmuch as such an enumeration would necessarily be incomplete. Often, and indeed most often, the counter is connected mechanically with the revolving shaft in such a way that a new figure shall appear at every revolution or at every oscillation. Under some circumstances, transmission is effected by electricity; at every revolution a current is sent into the circuit, and, entering the counter, acts on gearing which causes the new figure to appear. But more complicated cases may happen in which the indications of the counter cannot be obtained with the same facility; for example, when there are several independent apparatus, each having its own velocity, and where the counter must give at every instant, and at once, an indication of the total of the numbers corresponding separately to each of the shafts.

A case presented itself, for instance, at the gas works of Villette, which has ten meters, each of which gives, or can give passage simultaneously to 40,000 cubic meters of illuminating gas daily, or a total of 400,000 cubic meters. It was desired to have at each instant the total amount of delivery, from the beginning of the year, so that eventually might at once be known the total quantity of gas (possibly amounting to 146,000,000 cubic meters) that had been furnished to consumers.

As it was desired to have this datum at any moment whatever, day or night, a counter connected mechanically with the different revolving shafts could not be thought of, since this would have carried with it the necessity of entering the room with a light to make the readings—a condition that had to be avoided. It became necessary, then, to have recourse to electrical transmission. But here a difficulty presented itself; for the motions of the various gas meters, as we have said, are entirely independent. It might possibly happen then that at certain instants a concordance should exist between the deliveries made by two or more of these meters, and the different currents reaching the totalizer *simultaneously* would thereupon produce no more effect than a single one, the figure marked being increased by only one unit; and, too, the case, improbable though not impossible, might happen where the ten meters were at the same time at the same point of their revolution. If, by chance, this simultaneous action were prolonged for a certain time, the figure indicated for such a period would then be ten times too small.

M. Dumoulin Froment, who was commissioned with the construction of the apparatus, succeeded in obviating the above mentioned difficulty in a very ingenious manner.

We may in a few words recall the fact that theoretically a bar of soft iron becomes instantaneously magnetized and demagnatized under the influence of a current passing through a helix which surrounds the bar; this is what constitutes an *electro-magnet*. In reality, there is much magnetization under these conditions, but even in the softest iron the demagnetization is never complete at the moment the current ceases to pass. The soft iron always remains feebly magnetized—and there exists therein what is called *remanent magnetism*. The magnetism which continues if the iron is soft is never very strong, however; for although it may hold a bit of iron which is in contact with it, it is powerless to attract iron which is at even a short distance from it. This remanent magnetism, which must always be taken into account in all apparatus of precision where there are electro-magnets, is often an inconvenience. Sometimes, though rarely, its existence has been advantageously utilized, as in the case of the apparatus under consideration, of which Fig. 1 gives a general view simplified in the respect that the instrument shown is arranged to receive four instead of ten indications.

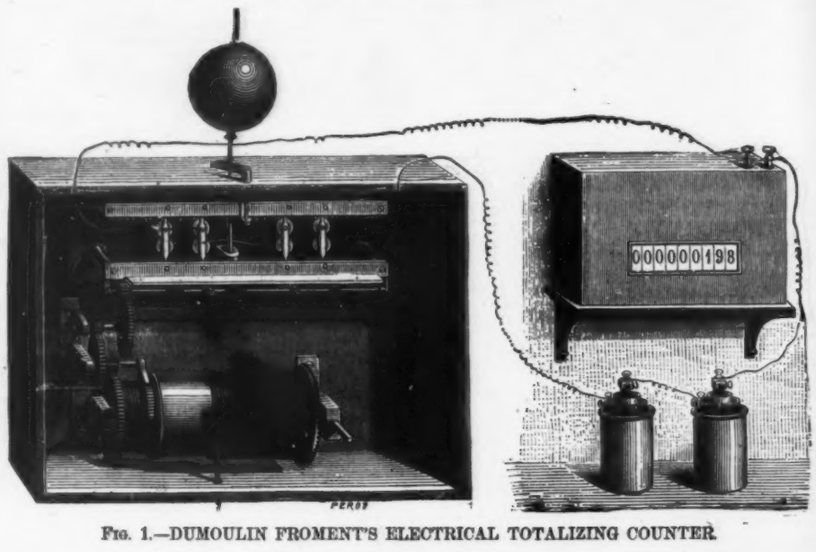


FIG. 1.—DUMOULIN FROMENT'S ELECTRICAL TOTALIZING COUNTER.

At the upper part of the box, which has here been supposed open, there are perceived four electro-magnets, the details of which are given in Fig. 2. Each of these is in communication with one of the gas meters, and is traversed by a current at the moment when a complete revolution is effected. To the right is seen an automatic counter which presents no peculiar arrangement, and which marks one new unit more every time that it receives a current. It will be necessary, then, for it to receive a current every time that one traverses an electro-magnet, while absolutely avoiding the possibility of two simultaneous emissions. To arrive at such a result, there is employed a distributer, which we shall describe.

In front of each electro-magnet, A, there is a strip of iron, B, which is held back from the poles of A by a spring. So long as this strip remains fixed against the electro-magnet, no current is sent to the totalizer by the apparatus; but, on the contrary, there will be an emission when the strip or armature leaves the electro-magnet as a consequence of the arrangement of certain details that are to be described. It is necessary, then, to prevent the two pieces, B, from each leaving its corresponding magnet at the same time; and this object is attained by regulating beforehand the moment at

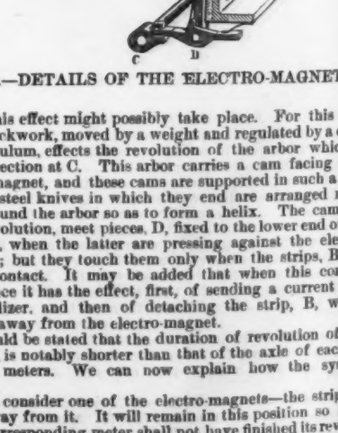


FIG. 2.—DETAILS OF THE ELECTRO-MAGNETS.

which this effect might possibly take place. For this purpose, clockwork, moved by a weight and regulated by a conical pendulum, effects the revolution of the arbor which is seen in section at C. This arbor carries a cam facing each electro-magnet, and these cams are supported in such a way that the steel knives in which they end are arranged regularly around the arbor so as to form a helix. The cams, in their revolution, meet pieces, D, fixed to the lower end of the strips, B, when the latter are pressing against the electro-magnets; but they touch them only when the strips, B, are not in contact. It may be added that when this contact takes place it has the effect, first, of sending a current into the totalizer, and then of detaching the strip, B, which remains away from the electro-magnet.

It should be stated that the duration of revolution of the arbor, C, is notably shorter than that of the axle of each of the gas meters. We can now explain how the system works:

Let us consider one of the electro-magnets—the strip, B, being away from it. It will remain in this position so long as the corresponding meter shall not have finished its revolution. At this moment a current will be sent into the electro-magnet, A, and the strip, B, will be attracted. The current passes for a very short time only, but the strip of iron remains fixed to the electro-magnet as a consequence of the action of remanent magnetism, and the totalizer receives

nothing. But by the revolution of the arbor, C, the cam acts at a certain moment, the armature is separated from the magnet (which cannot attract it without being traversed by a current, because the remanent magnetism is too weak to act at a distance), and at this instant a current is sent to the totalizer, which thereupon indicates one unit more. Supposing the electro-magnet to have acted immediately after the passage of the cam, the totalizer will mark a unit only after one complete revolution of the arbor; but that causes no difficulty, because, as we have said, the gas meters revolve more slowly than the arbor, C, and consequently the electro-magnet cannot act a second time before the cam has detached the armature, B. It will be understood that if this circumstance should occur, there would be one revolution of the meter that would not be marked. If, on another hand, we suppose the four gas meters to have ended their revolution together, the four electro-magnets will together attract the four armatures, but the four currents will be sent *successively* to the totalizer, since they will correspond with the successive passage of the cams before the pieces, D. The totalizer will, then, in all cases give the real indications. This elegant solution of a problem, which was not unattended with difficulty, has been affirmed practically, the apparatus having been now working for more than a year. In all respects, it will merit the detailed description that we have given of it. —*C. M. Gariel, in La Nature.*

[Continued from SUPPLEMENT No. 276, page 4400.]

GAS AND ELECTRICITY AS HEATING AGENTS.

By DR. C. W. SIEMENS, F.R.S., etc.

To illustrate the efficiency of this mode of heating the incoming air by what is called waste heat, I will show you another application of the same principle, which I have made very recently, to the combustion of gas for illuminating purposes. Gas engineers have until now been under the impression that a supply of cold air was favorable to the production of a brilliant flame. This is a misconception, which was very general also as regards the combustion of solid fuel in furnaces, until it was disproved by Stirling, by Neilson, and by the introduction of the regenerative gas furnace. The "duplex burner" owes its brilliancy to the heating effect of the one burner upon the other; and my brother, Mr. Frederic Siemens, has more recently constructed a burner in which the flame of the gas is reversed in its action, in order to heat in its descent the ascending current of flame-supporting air.

By the application of the principle of conduction before described, I obtain the hot-air current, in a most simple manner, without interfering with the free action of the flame. The construction of my burner is the same as an ordinary Argand burner, but it takes its supply of gas through an enlarged vertical copper tube. This copper pipe terminates in a rod of highly conductive copper, which passes upward through the burner, and carries at its top a ball of porcelain or other refractory material. The rod is coated with platinum or nickel to prevent oxidation when heated (almost to redness) by the heat of the flame. The tube is armed with radial plates of copper, presenting a considerable aggregate surface, and abutting externally against a covering of asbestos or other non-conductive material. The waste heat of the flame, or that portion of the heat produced in combustion which is not utilized in luminous rays, serves to heat the ball of refractory material and the conductive rod; and the heat is thus transferred by conduction to the tube, with its laminar radii, between the extensive surfaces of which currents of air are free to ascend toward the Argand burner. The air is thus heated to from 700° to 800° Fahr. before meeting the gas, and the ultimate temperature of the flame is increased to at least the same amount, causing a larger proportion of the heat developed in combustion to reach the point of luminous radiation.

But not only the quantity of light but its quality is improved by the higher temperature obtained. It may appear surprising, but it is a fact susceptible of accurate proof, that the light obtained in the consumption of a given amount of gas may thus be increased by some 40 per cent., and that in this large proportion the deleterious influences connected with gas lighting may be diminished. Gas will thus be better able to hold its position against its more brilliant rival, the electric light, except for such large applications as the lighting of public halls and places, of harbors, railway stations, warehouses, etc., for which it is pre-eminently suited. Add to these improved applications of gas the ever-increasing ones for heating purposes, and I have only to express regret that I am not a gas shareholder.

If, however, gas is to be largely employed for heating purposes, it will have to come down in price; and, considering that heating gas need not be highly purified, or be possessed of high illuminating power, the time will come, I believe, when we shall have two services, one for illuminating and the other for heating gas. In many towns two systems of gas mains already exist; and it would only be necessary to appropriate the one for illuminating and the other for heating gas. The ordinary retorts could be used for the production of both descriptions of gas, it being well known that even ordinary coal will give up gases of high illuminating power during a certain portion of the time occupied in their entire distillation. The gases emitted from the retort when first charged are to a great extent occluded gases of low illuminating power, such as fire-damp or marsh gas, and these should be turned into the heating gas mains. In the course of half an hour these occluded gases, together with the aqueous and other vapors, will have left the coal, which is then in the best condition to evolve olefiant gas and other gases rich in carbon, and therefore of high illuminating power. The period during which such illuminating gases are emitted extends over probably two hours, after which the retorts should again be connected with the heating gas mains, until the end of the process. The result of this *modus operandi* would be that the illuminating gas supplied, say, in London, would probably exceed 20-candle power from Newcastle coal, instead of 16 as at present, whereby the objectionable results of gas lighting would be greatly diminished, and there would be, say, an equal volume of heating gas available, consisting for the most part of marsh gas, which although greatly inferior to olefiant gas in illuminating effect, would be actually more suitable for heating purposes, because less liable to produce soot in its combustion.

The total cost of production would not be increased by this separation of the gases, and the price might, with advantage both to the supplier and to the consumer, be so adjusted that the latter, while paying for his illuminating gas an increased price, proportionate to the increase of illuminating power, would be furnished with a heating gas at greatly reduced cost; for the heating gas could be reduced in price in a much larger proportion than the illuminating gas would have to be raised, because it would not require the same purification from sulphur, which renders illuminating gas comparatively costly. The enormous increase of consumption would, moreover, enable the gas companies to reduce prices all round very considerably, without interfering with their comfortable revenues.

For large applications of heating gas to the working of furnaces and boilers, simpler means than the retort can be found for its production. I need not now describe in detail the gas producer which I constructed many years ago in connection with my regenerative gas furnace. In it all the carbonaceous matter of the coal is converted into combustible gas, the solid carbon yielding a supply of carbonic oxide. The resultant mixture of combustible gas contains a very large proportion—averaging 61·5 per cent.—of nitrogen, which swells its volume without in any way contributing to its heating power.

It has been my endeavor for some time to construct a gas producer which, without losing the simplicity of the first, should be capable of yielding a heating gas of superior calorific power. This producer consists of a wrought iron cylindrical chamber, truncated downward, and lined with brickwork. The fuel to be converted into gas is introduced throught a hopper, and the cinder and ashes work out through the open orifice at the bottom. Instead of a grating for the introduction of atmospheric air, a current of heated air is brought in, either through the hopper or through the orifice at the bottom, and is discharged into the center of the mass of fuel. The effect is the generation of a very intense heat at that point. The fuel, after its descent through the hopper, arrives gradually at this region of intense heat, and when subjected to it, parts with its gaseous constituents. At the point of maximum heat coke is consumed, producing carbonate anhydride, which, in passing through the considerable thickness of fuel surrounding this portion, takes up a second equivalent of carbon, and becomes changed into carbonic oxide. Here also the earthy constituents are for the most part separated in a fused or semi-fused condition, and in descending gradually reach the orifice at the bottom, whence they are removed from time to time. Air enters through the bottom orifice to some extent, causing the entire consumption of the carbonaceous matter which may have got past the zone of greatest heat. Water is also here introduced in a hollow tray; and, after evaporation by the heat of the hot clinkers, passes upward through the incandescent mass, and is converted by decomposition into carbonic oxide and hydrogen gas. The exit orifices for the gases are placed all round, near the circumference of the chamber, ascending upward into an annular space, whence they are taken through pipes to the furnace or other destination.

The advantages connected with this *modus operandi* consist in the intensity of the heat produced within the center of the mass, whereby the whole of the fuel is converted into combustible gases, with the least amount of nitrogen. The hydrocarbons formed in the upper portion of the apparatus have to descend through the hotter fuel below, and in so doing the tar and other vapors mixed up with them are decomposed, and furnish combustible gases of a permanent character.

The orifice at the bottom of the apparatus may be enlarged and so arranged that instead of ashes only being produced coke may be withdrawn, and in this way a continuous coke oven may be constructed, which is at the same time a gas producer, or, in other words, an apparatus in which both the solid and gaseous constituents of the coal are fully utilized. The intense heat in the very center of a large mass of fuel has for its result a very rapid distillation, and thus one gas producer does the work of two or three gas producers of the type hitherto employed. This more concentrated action will, moreover, allow of the introduction of gaseous fuel, where want of space and considerations of economy have militated hitherto against it and in favor of the ordinary coal furnace.

It has been already proved that steam boilers can be worked economically on land with gaseous fuel, and there is no reason that I know of why the same mode of working should not also be applied to marine boilers. The marine engine has within the last fifteen years been improved to an extent which is truly surprising. The consumption of coal, which at the commencement of that period was never less than 8 lb. per horse power, has been reduced by expansive working in compound cylinders to 2 lb., or even less, per actual horse power. The mode of firing marine boilers has, however, remained the same as it was in the days of Watt and Fulton. In crossing the Atlantic one may see a considerable number of men incessantly employed in the close stoke-hole of the vessel, opening the fire-doors and throwing in fuel. Each charge gives rise to the development of great clouds of black smoke issuing from the chimney, to the great annoyance and discomfort of the passengers on deck. If, instead of this, the fuel could be discharged mechanically into one or more gas producers, the gaseous fuel produced would maintain the boilers at a very uniform heat, without necessitating the almost superhuman toil of the fireman; no smoke or dust would be emitted from the chimney, and a large saving of fuel would be effected. This change would be specially appreciated by the numerous tourists visiting the Western Highlands. Speaking from my own experience on one occasion, I may say that the pleasure of a trip on the beautiful Loch Lomond was very seriously marred in consequence of the fumigation which my fellow passengers and myself had to endure.

The change from the use of solid to gaseous fuel would be the prelude probably to another, and still more important change—namely, the entire suppression of the steam boiler. We are already in possession of gas engines working at moderate expense as compared with small steam-engines, even when supplied with the comparatively expensive gas from our town gas-mains, and all that will be required is an extension of the principle of operation already established. The realization of such a plan would, of course, involve many important considerations, and may be looked upon as one of those subjects the accomplishment of which may be left for the energy and inventive power of the rising generation of engineers.

Before leaving this branch of the subject, I wish to call attention to a favorite suggestion which I had occasion to make some years ago. It consists in placing gas producers at the bottoms of the coal mines themselves, so that instead of having to raise the coal by mechanical power, the combustible gases ascending from the depth of the mine to the surface would acquire, by virtue of their low specific gravity, such an onward pressure that they could be conducted in tubes to distances of many miles, thus saving the cost of raising and transporting the solid fuel. Glasgow, with its adjoining coal-fields, appears to me a particularly favorable locality for putting such a plan to a practical trial, and the well-known enterprise of its inhabitants makes me sanguine of its accomplishment. When thus supplied with gaseous fuel, the town would not only be able to boast of a clear atmosphere, but the streets would be relieved of the most objectionable portion of the daily traffic.

I now approach another and the last portion of my address—the attainment of very intense degrees of heat either for effecting fusion or chemical decomposition. Although, by means of the combustion of either solid or gaseous fuel, heats are produced which suffice for all ordinary purposes, there is a limit imposed upon the degree of temperature attainable by any furnace depending upon combustion. It has been shown by Bunsen and by St. Claire Deville, that at certain temperatures the chemical affinity between oxygen on the one hand and carbon and hydrogen on the other absolutely ceases, and that if the products of combustion—carbonic acid and water—be exposed to such a degree of temperature, they would fall to pieces into their constituent elements. This point of dissociation, as it is called, is influenced by pressure, but has been found for carbonic acid under atmospheric pressure to be 2,600° C. (4,700° Fahr.) But long before this extreme point has been arrived at, combustion is greatly retarded, and the limit is reached when the losses of heat by radiation from the furnace balance its production by combustion.

To electricity we must look, then, for the attainment of a temperature above that of dissociation, and we have evidence of the early application of the electric arc to such a purpose. In 1807 Sir Humphry Davy succeeded in decomposing potash by means of an electric current from a Wollaston battery of 400 elements, and in 1810 he surprised the members of the Royal Institution by the brilliant electric arc produced between carbon points through the same agency.

Magneto-electric and dynamo-electric currents allow of the production of the electric arc much more readily and economically than by the use of Sir Humphry Davy's gigantic battery, and Messrs. Huggins, Lockyer, and Liveing, and other physicists have taken advantage of the comparatively new method to advance astronomical and chemical research with the aid of spectrum analysis.

My object is now to show that the heat of the electric arc is not only available within a focus or extremely contracted space, but that it is capable of producing such larger effects as will render it useful in the arts for fusing platinum, iridium, steel, or iron, or for effecting such reactions or decompositions as require for their accomplishment an intense degree of heat, coupled with freedom from such disturbing influences as are inseparable from a furnace worked by the combustion of carbonaceous material.

The apparatus which I employ to effect the electro-fusion of such material as iron or platinum consists of an ordinary crucible of plumbago or other highly refractory material, placed in a metallic jacket or outer casing, the intervening space being filled up with pounded charcoal or other bad conductor of heat. A hole is pierced through the bottom of the crucible for the admission of a rod of iron, platinum, or dense carbon, such as is used in electric illumination. The cover of the crucible is also pierced for the reception of the negative electrode, by preference a cylinder of compressed carbon of comparatively large dimensions. At one end of a beam, supported at its center, is suspended the negative electrode by means of a strip of copper or other good conductor of electricity, the other end of the beam being attached to a hollow cylinder of soft iron, free to move vertically within a solenoid coil of wire, presenting a total resistance of about fifty units or ohms. By means of a sliding weight the preponderance of the beam in the direction of the solenoid can be varied so as to balance the magnetic force with which the hollow iron cylinder is drawn into the coil. One end of the solenoid coil is connected with the positive, and the other with the negative pole of the electric arc, and, being a coil of high resistance, its attractive force on the iron cylinder is proportional to the electromotive force between the two electrodes, or, in other words, to the electrical resistance of the arc itself.

The resistance of the arc was determined and fixed at will within the limits of the source of power, by sliding the weight upon the beam. If the resistance of the arc should increase from any cause, the current passing through the solenoid would gain in strength, and the magnetic force overcoming the counteracting weight would cause the negative electrode to descend deeper into the crucible; whereas, if the resistance of the arc should fall below the desired limit, the weight would drive the iron cylinder within the coils, and the length of the arc would increase until the balance between the forces engaged is re-established.

Experiments with long solenoid coils have shown that the attractive force exerted upon the iron cylinder is subject only to slight variation within a range of several inches, which circumstance allows of a working range, to that extent, of nearly uniform action on the electric arc.

This automatic adjustment of the arc is of great importance to the attainment of advantageous results in the process of electric fusion. Without it the resistance of the arc would rapidly diminish with increase of temperature of the heated atmosphere within the crucible, and heat would be developed in the dynamo-electric machine to the prejudice of the electric furnace. The sudden sinking or change in electrical resistance of the material undergoing fusion would, on the other hand, cause sudden increase in the resistance of the arc, with a likelihood of its extinction, if such self-adjusting action did not take place.

Another important element of success in electric fusion consists in constituting the material to be fused the positive pole of the electric arc. It is well known that it is at the positive pole that the heat is principally developed, and fusion of the material constituting the positive pole takes place even before the crucible itself is heated up to the same degree. This principle of action is, of course, applicable only to the melting of metals and other electrical conductors, such as metallic oxides, which constitute the materials generally operated upon in all metallurgical processes. In operating upon non-conductive earth or upon streams of gases, it becomes necessary to provide a non-destructible positive pole, such as is supplied by the use of a pool of fused platinum, or iridium, or by a plumbago crucible. In working the electric furnace, some time is taken up in the first instance in raising the temperature of the crucible to a considerable degree, but it is surprising how rapidly an accumulation of heat takes place. In using a pair of dynamo machines capable of producing seventy webers of current with an expenditure of seven-horse power, and which, when used for purposes of illumination, produce a light of twelve thousand candles, a crucible of about eight inches in depth, immersed in a non-conductive material, has its temperature raised to a white heat in fifteen minutes, and four pounds of steel are fused within another fifteen minutes, successive fusions being effected in somewhat diminishing intervals of time. The process can be carried on upon a still larger scale by increasing the power of the dynamo machines and the size of the crucibles.

The purely chemical reaction intended to be carried into effect within the crucible, might be interfered with through the detachment of particles from the dense carbon used for the negative pole, although its consumption within a neutral atmosphere is exceedingly slow. To prevent this I have used, both in this connection and also in the construction of electric lamps, a water pole or tube of copper through which a current of water circulates, so that it yields no substance to the arc. It consists simply of a stout copper cylinder closed at the lower end, having an inner tube penetrating to near the bottom, for the passage of a current of water into the cylinder, which water enters and is discharged by means of flexible India-rubber tubing. This tubing being of non-conductive material, and its sectional area small, the escape of current from the pole to the reservoir is so slight that it may be neglected. On the other hand, some loss of heat is incurred through conduction, with the use of the water pole, but this loss diminishes with the increasing heat of the furnace, inasmuch as the arc becomes longer, and the pole is retired more and more into the crucible cover.

In the experiments which I shall now place before you, the current which has supplied the one electric lamp in the center of the hall will be diverted by means of a commutator through the electric furnace. After it has been active for five minutes to warm the crucible, I shall charge it with eight pounds of broken steel files, which I shall endeavor to melt and pour out into an ingot mould before your eyes.

By some obvious modifications of this electric furnace it can be made available for a variety of other purposes where intense heat is required combined with immunity from disturbing chemical actions. By piercing a number of radial holes through the sides of the chamber, and introducing the ends of wires through the same, an excellent means is provided of heating those wire ends very rapidly, without burning them, for the purpose of welding them together. The electrical furnace will also be found useful, I believe, in the hands of the chemist, to effect those high temperature reactions between gaseous bodies which require the employment of temperatures far exceeding the hitherto available limits, and will thus increase the area of available reactions at his disposal for the attainment of either scientific or practical ends.

I have endeavored to compress within the limited space of a single lecture, subject matter that might occupy the close attention of the student for weeks or months, and I may, therefore, be pardoned if I have failed to convey to you more than a very rough outline of what may be accomplished by the judicious use of gaseous fuel and of the electric current as heating agents.

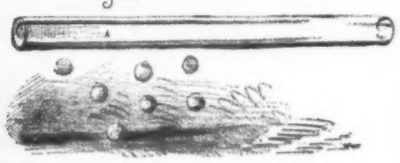
SIMPLE HOLTZ ELECTRICAL MACHINE, AND SOME EXPERIMENTS IN STATIC ELECTRICITY.

By GEO. M. HOPKINS

BEFORE considering the construction of the electrical machine and the experiments that may be performed with it, I will describe briefly some of the manifestations of frictional electricity which may be exhibited without a machine, and which, although pretty well known, are nevertheless interesting.

Frictional electricity is not inherent in bodies, but is evoked by friction, pressure, and a variety of other causes of which it is unnecessary to speak at present. Friction between

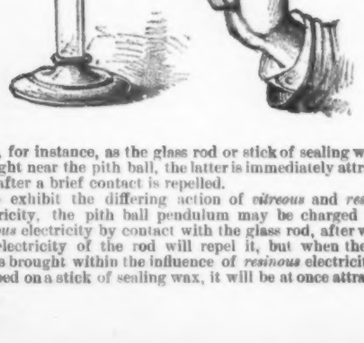
Fig. 1.



almost any class of substances will develop electricity; the simplest way of showing this is to rub a glass rod or stick of sealing wax with a piece of flannel or silk, and hold it over bits of paper or small pith balls, as shown in Fig. 1. The bits of paper or the balls leap at once to the glass rod or stick of sealing wax, and after becoming electrified they are repelled; after losing their charge they are again attracted and repelled, and so on.

The electrical pendulum, shown in Fig. 2, is a simple device for ascertaining whether bodies are electrified or not. It consists of a pith ball suspended by a silk fiber from a wire attached to a glass support. When an electrified body,

Fig. 2.



such, for instance, as the glass rod or stick of sealing wax, is brought near the pith ball, the latter is immediately attracted and after a brief contact is repelled.

To exhibit the differing action of *vitreous* and *resinous* electricity, the pith ball pendulum may be charged with *vitreous* electricity by contact with the glass rod, after which the electricity of the rod will repel it, but when the pith ball is brought within the influence of *resinous* electricity developed on a stick of sealing wax, it will be at once attracted.

The electroscope in its simplest form is shown in Fig. 3. It is far more sensitive than the electrical pendulum, and may be used in many curious and instructive experiments. It consists of a small flask or bottle, through the stopper of which is inserted a brass wire having at its upper end a metal ball and at its lower end a hook bent out horizontally to receive two strips of very thin metal leaf, either Dutch-metal leaf, silver or gold leaf, or aluminum leaf; the latter I have found the most sensitive, probably on account of its extreme lightness. The strips, which are three-eighths inch wide and two inches long, are fastened to the top of the wire hook by means of gum or even saliva alone.

To determine whether a body is electrified present it to the ball. If the leaves diverge electricity is present. A slight touch of a glass rod, a rubber comb or ruler, or a wooden ruler, upon the clothing, or carpet, or even upon a wooden surface, develops electricity in sufficient quantities to affect the electroscope. It is wonderful to note how little friction is required to evoke a perceptible amount of electricity. One movement of the clothes brush upon the clothes or carpet affects the electroscope from a long distance. A feather duster brushed once over a varnished chair will cause the leaves of the electroscope to diverge at a distance

Fig. 3.

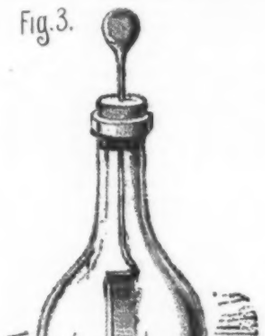
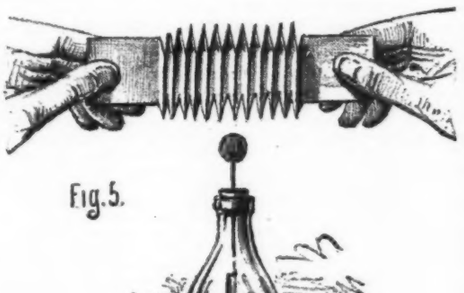


Fig. 5.



of eight to ten feet. An ordinary elastic rubber band drawn across the edge of the desk develops sufficient electricity to widely diverge the leaves. The rubber band affords a curious example of the distribution of electricity on an extensible surface. If after electrifying the rubber band it is held over the electroscope, and alternately elongated and allowed to contract, the leaves of the electroscope will be seen to converge when the band is stretched, and to diverge when the band contracts.

If a piece of paper, folded like a fan and well dried, is struck several times with a silk handkerchief and afterward alternately closed and opened over the electroscope as shown in Fig. 5, the reverse of what occurred in the case of the rubber band will happen. That is, when the paper is stretched out the leaves will diverge, and when it is closed up they will fall together, showing that in the latter case the electricity is marked.

There are many other interesting experiments that may be tried with the electroscope in connection with simple objects that may be found anywhere.

After the experimenter has exhausted his resources for experiments of a simple character, an electrical machine will be required, and, as is very well known, there is no machine that can compare in efficiency or cheapness with the Holtz, and there are numbers of our experimenters and students who would hardly feel warranted in purchasing one of them, who would construct one but for a few difficulties which at first sight seem almost insurmountable to the tyro. The questions that beset the inquirer are: (1) What kind of glass shall be used? (2) How shall the glasses be apertured? (3) How shall the parts be adjusted and manipulated to secure the wonderful results attained by this machine?

It is the object of this article to fully answer these queries, and to give such details of construction as to enable any one having even a moderate mechanical ability to make, in a very simple manner, a machine fully as efficient as the best in market, and that, too, without any considerable outlay for materials. Without describing in detail the principle upon which the machine operates—these matters being fully treated in all works on physics—I will describe a machine which was made in odd moments as a matter of recreation, and which is as efficient as could be desired, yielding a spark fully six inches in length, equivalent to one half of the diameter of the rotating disk. This machine is shown in perspective in Fig. 6. Different forms of apertured disk are shown in Figs. 7, 8, and 9.

The glass for the disks is selected from common window glass. It should be as thin as possible, of uniform thickness, and flat. It is not essential that the glass be absolutely free from imperfections, although this is desirable. The rotating disk is twelve inches in diameter, the fixed disk is fourteen inches in diameter. I begin with the glass disks, as it is here that most of the difficulty in making the machine is supposed to lie, the especial trouble being in making the aperture in the revolving glass for receiving its hollow shaft, and in making the three large apertures in the fixed glass. I dispense with the hole in the revolving disk and secure it to a vulcanite collar, by means of a cement composed of pitch, gutta percha, and shellac, equal parts, melted together. The method of applying the cement for this purpose is to warm the vulcanite collar, then cover it with a thin layer of the cement; then, after making the glass rather warm, lay it on a paper on which are described two concentric circles, one the size of the glass disk, the other the size of the collar, and while the glass is still hot quickly press the collar down upon it. The vulcanite collar is screwed on the end of a wooden sleeve, C, having at one end a shoulder to receive the collar and at the other end a small pulley to receive the driving belt. The sleeve, C, turns upon a piece of three-eighths inch brass tubing, which extends through the vertical post, D, ten inches high and two inches in diameter. The end of the sleeve, C, next the glass disk, B, is countersunk to receive a screw which enters the end of the brass tube holding the sleeve in place. This screw is

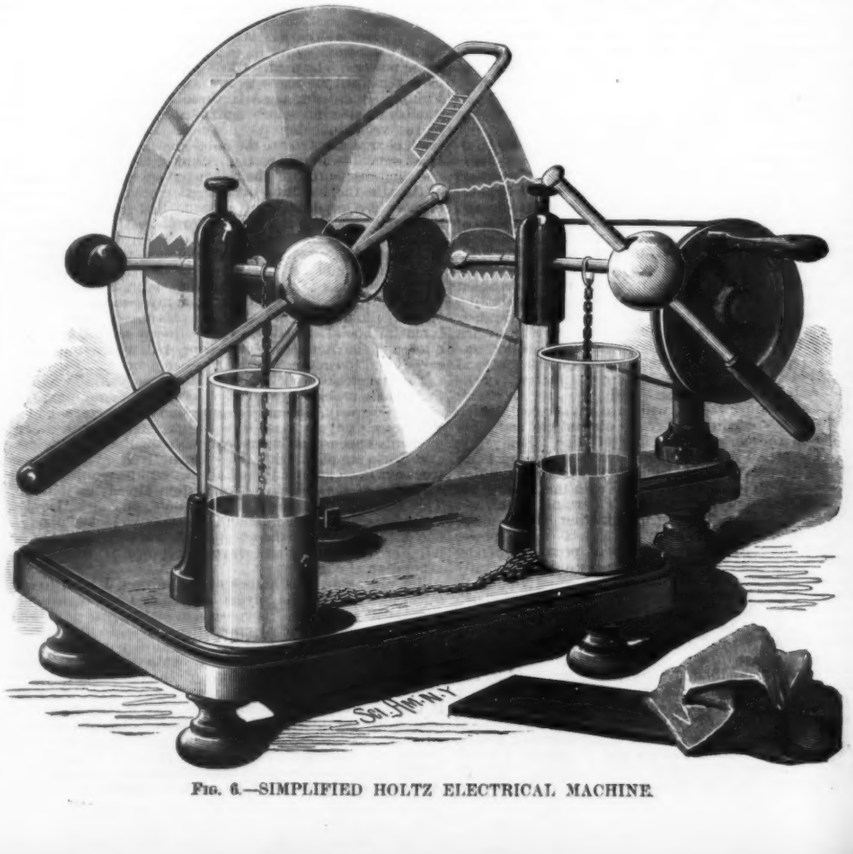


FIG. 6.—SIMPLIFIED HOLTZ ELECTRICAL MACHINE.

covered by the glass when the revolving disk is in its place in the machine.

The internal thread of collar is formed with a chaser, and as it is difficult to screw the collar directly on the wood, I first wrap the end of the wooden sleeve with leather, which is glued fast. The vulcanite readily screws over the leather, forming the thread as it goes. This is a little unmechanical, but it is extremely efficient and saves a great deal of trouble.

The glass for stationary or apertured plate, A (see Figs. 6 and 8), is first cut in circular form and then divided diametrically, and the apertures are formed by cutting half from each plate, a very simple matter as com-

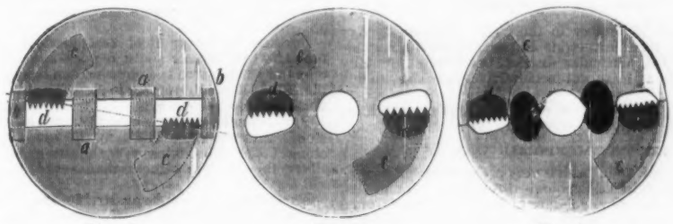


FIG. 7. FIG. 9. FIG. 8.

APERTURED DISKS.

pared with cutting the three holes from an entire disk. The lateral holes are two and three-quarter inches long, and one and three-quarter inches wide at the larger end, and their sides are nearly on radial lines, extending from the center of the disk. The central opening through which the sleeve, C, extends is approximately circular, but is sightly elongated at *e e*, to facilitate the removal of the portion cut out. Of course the simplest way to get the glass into the desired shape is to have a glazier cut it with his diamond, but any one may do it with one of the twenty-five cent steel roller glass cutters sold everywhere. The disks of the machine represented were cut in this way, and the notches in the semicircles of the fixed disk were cut with one of these inexpensive yet useful tools. The only precaution necessary in cutting the notches is to make them rather flaring to permit of the removal of the piece after it is cut.

The two halves of the fixed disk are fastened together by two elliptical pieces of glass cemented to the two halves, between the central and lateral openings. The cement used is the same as that above described, and it is applied in a similar manner. The cement known as "stratena" answers very well for this purpose, but it must have several days to dry before the machine can be used.

The edges of the glass around the apertures and along the seams should be varnished with the best quality of alcoholic shellac varnish, to prevent the accumulation of moisture.

Paper inductors, *c*, are attached to opposite sides of the apertured glass by means of starch paste, made by cooking

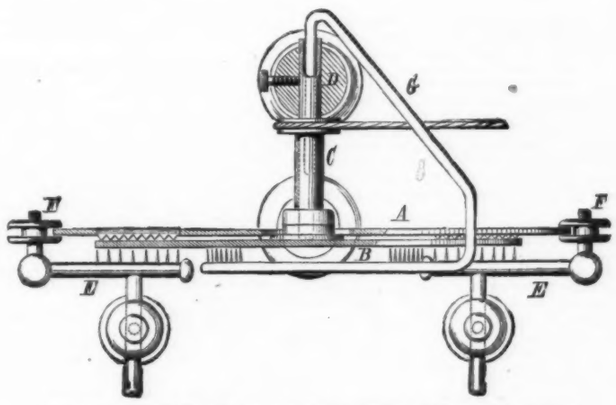


FIG. 10.—PARTIAL PLAN OF SIMPLIFIED HOLTZ MACHINE.

starch until it begins to thicken, and cooling it before it becomes clear, *i. e.*, while it is still of milky whiteness. These inductors are made of filter paper or of single thick drawing paper, and extend from the lateral openings or windows about one-third the distance between the two windows in a circular direction. The outer edges of the inductors are arranged on a circle one-eighth inch smaller than the revolving disk. At the end of each inductor, and upon the opposite sides of the glass, are pasted pieces, *d*, of gilt paper, which project straight into the window, and when dry are serrated, the points of the teeth being on the center line of the windows.

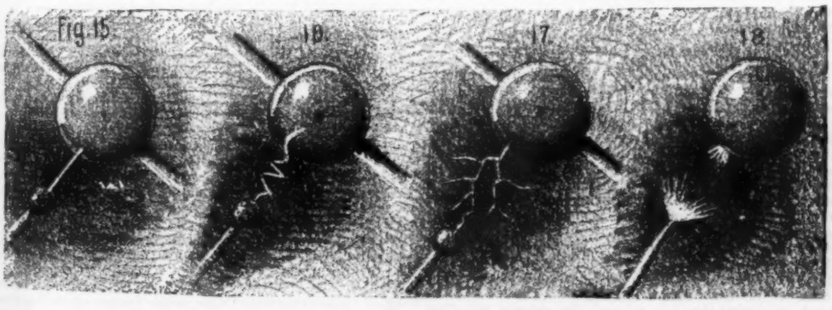
In front of the revolving plate, B, two combs or collectors, E, are supported upon glass columns having wooden bases and tops. These combs are made of three-eighths inch brass tubing, the two pieces being fitted together and fastened with soft solder. The points, which are simply cut off bank pins, are driven into holes in the brass tube, three-eighths inch apart. The inner ends of the tubes forming the combs are soldered to brass ball buttons; the outer ends are inserted in wooden balls, from which wooden screws extend backward to receive the deeply-grooved wooden nuts, F, which hold the edges of the apertured disk, A. The points of the combs each cover a space two and one-half inches long, or about equal to the width of the paper inductors. Care should be taken to avoid bringing the inner ends of the combs nearer together than is absolutely necessary, as the striking distance of the spark must be less than this distance. The outer point of the comb should be at least one eighth inch from the periphery of the revolving plate. The points should be as near the face of the revolving glass as possible without touching. The combs are clamped in place by wooden screws in the wooden tops of the glass standards.

The outer ends of the tubes supporting the combs are fitted to tubes soldered in the large hollow balls. Through these balls the discharging rods, slide with a gentle friction. The inner ends of the discharging rods are provided with spherical knobs, and their outer ends are fitted with vulcanite handles.

The cross-arm, G, instead of being supported from the center, as usual with the apertured revolving plate, is elongated and bent so as to enter the rear end of the tube which forms the bearing for the sleeve, C. It is split to create friction in the tubes to retain it in position, and in addition to this the screw which holds the tube in the post, D, passes through a hole in the tube, and bears against the extension of the cross-arm.

The free end of the cross-arm is carefully rounded, and the pins correspond in number and position to those of the combs, E. The cross-arm, when the machine is in use, is placed opposite the ends of the paper inductors, as shown in the illustration.

The lower edge of the apertured plate, A, rests in an adjustable support on the table.

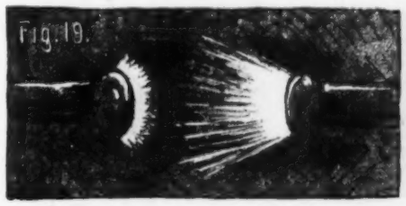


The base of the machine is provided with an extension for receiving the standard of the driving pulley, which is made adjustable on the table to tighten the belt, the table being slotted to receive the screw projecting downward from the standard, and the foot of the table answering as a nut to clamp the standard in any desired position. The pulley on the sleeve is one and one-half inch in diameter, and the driving pulley is six inches in diameter. Almost any kind of belting will answer, but a gut string is preferable.

To complete the machine, two condensers or small Leyden jars are required. These may vary in size. The intensity of the spark increases, and the rapidity of the discharge decreases, with an increase in the size of the jar. In the machine shown they are two and one-half inches in diameter and six inches high, and are covered on the inner and outer side with tin foil to within three inches of the top, the starch paste before mentioned being used to fasten the foil. The uncovered portion of the jar is varnished with shellac. If jars of the desired form and proportion are not obtainable, bottles may be readily cut by means of a hot curved rod of iron about one quarter of an inch in diameter.

The condensers are placed outside the glass columns under the tubes that support the combs, and a small chain hanging on each tube touches the tin foil lining of the jar.

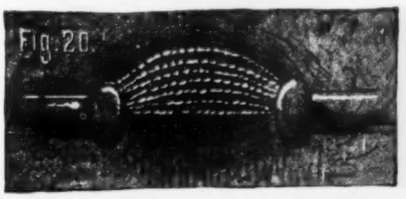
The outer coatings of the jars are connected by a small brass chain lying on the table. The plate, A, should be placed about three-sixteenths of an inch from the plate, B,



and it must be turned so that the edge of the windows to which the gilt paper is attached is exactly opposite the teeth of the combs, E.

To charge the machine, the ends of the discharge rods are brought into actual contact, and a piece of vulcanite from one-eighth to a quarter of an inch thick, four inches wide, and eight or ten inches long, is rubbed with a catskin, a piece of flannel, or a piece of silk, and applied to one of the paper inductors. At the same moment the machine is turned toward the gilt paper points. A strong smell of ozone and an increased resistance to turning are the first indications of the successful charging of the machine. Now, by slowly separating the discharge rods, the spark will pass over an increased distance, until it is fully six inches long. To produce the silent discharge, all that is required is to remove the chain on the table from one of the jars. No special directions are required as to the management of the machine. A dry atmosphere is favorable to its action, and it should be kept free from dust. Air currents interfere with its operation; therefore it should be used in a room with the doors and windows shut.

I have so far described only one form of apertured plate. In Fig. 7 is shown a form in which the disk has a central portion, one and five-eighths inch wide, removed, and the two parts are connected by glass strips, *a a* and *b b*, cemented in the manner already described. When this form of plate is

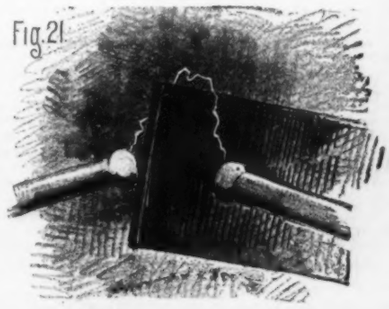


used, the combs must be inclined to correspond to the direction of the edges to which the gilt paper is attached. Fig. 9 shows the usual form of plate which requires the aid of the glass-cutter, as the holes cannot be readily made by one unused to operations of this kind; and, even if it were possible to do it readily, there would be no advantage in it.

The appearance of the spark when the two electrodes are separated only a short distance is shown in Fig. 15. It leaps in a straight line from one electrode to another. When the distance between the electrodes is greater, the spark takes a zigzag course, as shown in Fig. 16; and when a very long space separates the electrodes, the appearance of the spark is like Fig. 17. In Fig. 18 the discharge of positive electricity to a point is exhibited, and in Fig. 19 the ends of the discharge rods are shown as they appear when a considerable distance apart, the machine being arranged for the silent discharge.

The multiple appearance of the small spark of the silent discharge, when the discharge rods are near together, is shown in Fig. 20.

The report of the discharge is increased when the rubber plate is held between the rods, J, as in Fig. 21, the spark



jumping over the edge of the rubber in a very curious manner. Thick cardboard placed in this position is readily perforated, and the spark will pass through a pamphlet one-fourth inch thick.

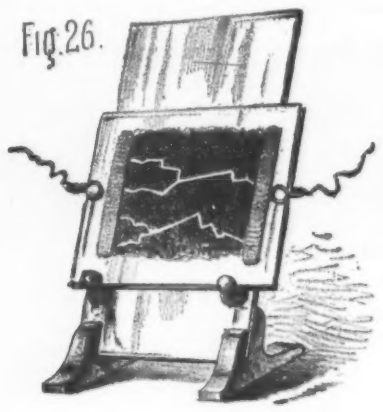
The electric discharge over finely divided metallic substances is very striking, and fully illustrates the saying that "there is no telling where lightning will strike."

Fig. 26 shows a glass plate which may be six or eight inches square. It is covered with a coat of thick shellac varnish or other suitable cement, and is thickly sprinkled with brass or iron filings before the varnish begins to dry. When the varnish is thoroughly dry a band of tin foil is pasted across opposite ends of the glass. When opposite ends of this plate are connected with the conductors of the

machine by a wire or otherwise, the discharge takes various courses over the filings, and when the machine is arranged for the silent discharge, the brilliancy of the spark is diminished while the rapidity of the discharge is greatly increased. Any body such as coin placed on the plate seems to have a determinative influence on the path of the spark, but it does not always determine it.

For convenience in exhibiting this class of experiments I have contrived an easel (shown in Fig. 26), which consists of a thick pane of glass supported in a slightly inclined position by two wooden feet. Two knobs furnished with large

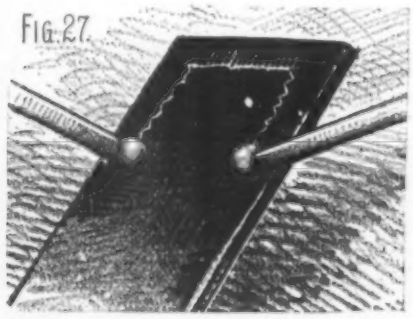
Fig. 26.



flanges are cemented to the glass near its lower edge. The knobs should be sufficiently long to receive a tube or anything of that nature which it is desired to exhibit.

To conveniently connect the luminous panes with the machine two U-shaped springs may be clasped on the edges of the glass, and connected with the machine by large wires. Unless chains with soldered links can be procured, wires or rods with rounded ends are to be preferred for making electrical connections, as chains afford numerous points for escape of electricity.

Fig. 27.



A curious exhibition of the diversion of the electric discharge by exceedingly slight causes is shown in Fig. 27. In this case the end of the vulcanite plate used to excite the machine is moistened with the tongue. It is then placed against the ends of the discharge rods (placed two inches apart) and moved along so as to make a tracing of the moisture along the surface of the rubber. The discharge will follow these lines of moisture, however slight they may be, in preference to traversing the shorter path between the two electrodes.*

SILVER IN SEDIMENTARY ROCKS.

THE following paper was read by A. W. Jackson at a recent meeting of the California Academy of Sciences, San Francisco.

Widespread interest has recently been developed in the subject of the occurrence of silver ores in sandstones and related sedimentary rocks, by the success which has attended the development of the famous Silver Reef mines in Southern Utah. These mines ship regularly between $70,000 and $80,000 worth of bullion per month, most of which is derived from ores taken from two or three strata of sandstone, a rock which, like most sedimentary rocks, is continuous over many square miles of territory.

This certainly must seem passing strange to the Pacific coast miner, who has been accustomed to consider that if there is any place where ores of the precious metal are *not* to be sought, it is in the sandstones and related sedimentary rocks.

The question is at once suggested: If precious metal is found in the sandstone of Utah, may it not be found in the sandstone of other districts? Has the prospector, who has, with such untiring energy, explored the most inaccessible recesses of our highest mountain chains in search of silver and gold, entirely overlooked a source of wealth which may be hidden in the monotonous sedimentary rocks of our plains and valleys? Finally, is there any practical consideration which guides the prospector which can tell him that in one locality he would seek fruitlessly for gold or silver, while in another he may hope to find it?

I think it can be shown that there is.

To the miner these are intensely

PRACTICAL CONSIDERATIONS.

If argentiferous and auriferous ores are to be sought indiscriminately in all of our sedimentary rocks, then there is scarcely an acre of the surface of the dry land but must be investigated, to prove either the presence or absence of ore. I am the more desirous of presenting a few thoughts on this subject for two reasons. On the one hand, prospectors have more than once recently sent sedimentary material to the geological department of the University, with a query as to whether ore deposits of the precious metals might be sought in them. On the other hand, one of the leading geologists of the country, Prof. Newberry, of Columbia College, New York, has announced a theory of the formation of the silver sandstone deposits at Silver Reef which, pushed to its legitimate conclusion, would necessitate the investigation, as I said before, of almost every acre of sedimentary rock in every country before the miner could be satisfied that gold or silver did not exist in it.

Now, I am aware that geology is far from being an exact science; furthermore, that that particular portion of it which deals with the genesis of ore deposits is one of the least understood. It is truly astonishing, when one reflects, that some of the fundamental principles of an industry which yearly adds hundreds of millions of dollars to the wealth of the country, should be so little understood.

However, while it is true that we know comparatively little about the

GENESIS OF ORE DEPOSITS,

still, we are not altogether in the dark. In almost every mining district, there are certain empirical laws which guide the miner in that particular district, but which are totally inapplicable, or at least not necessarily applicable, to any other district.

The laws of the occurrence of gold and silver, which are of general application, are exceedingly few.

THE TYPICAL MINERAL VEIN.

The "true fissure vein," as it is very properly called, is very simple in its structure and geological relations. It consists, essentially, of a fracture or fissure of a rock, varying from a fraction of an inch to many feet in width, of moderate length, rarely more than two or three miles, and of indefinite depth. This fissure becomes subsequently filled from side to side with ore and veinstone, probably introduced in the form of solutions from below. Very little obvious connection between the neighboring rocks and the contents of the fissure is observed. The bulk of the ore is confined almost entirely between the two walls of the fissure. It is often noticed, however, that the ore wanders out laterally into the wall rocks in sufficient quantities to render them worth mining, and, to a much less extent than this, even to very considerable distances. This takes place, too, under circumstances where the conditions would seem to be exceedingly unfavorable, as in solid granite and similar rocks.

Special attention is called to this lateral impregnation of the country rocks, as it has an important bearing upon the genesis of the ore in the sedimentary deposits. The essential

CHARACTERISTICS OF FISSURE VEINS

are, then, indefinite extension in depth, very moderate width (or thickness), and length, and subsequent formation to the inclosing rock.

The structure and geological relations of sedimentary rocks are in many respects quite the reverse of these. Take sandstone as a typical instance. It generally exists in the form of a widely extended horizontal deposit, covering many, often hundreds, of square miles, and varying in thickness from a few feet to thousands of feet. Other stratified rock often lie both above and below it, and it is always younger than the underlying and older than the overlying material.

Suppose such a body of rock to be impregnated with silver ore more or less throughout its whole extent; you at once comprehend the vast difference in mode of occurrence between such an ore-body and the typical mineral vein previously described.

Such in general is the mode of occurrence of the ore at Silver Reef, Utah. I am indebted to Prof. Newberry and to Mr. Rolker, for several years and until quite lately superintendent of the Stormont Mine, for the facts concerning these mines; particularly to the latter gentlemen, who has recently communicated a paper to the American Institute of Mining Engineers, upon the Leeds district mines, which was abstracted from the S. F. *Mining and Scientific Press*, December 25, 1880. I have not been able to consult Mr. Rolker's original paper, but have been compelled to content myself with the above-mentioned abstract.

I will not present a detailed description of the entire district and deposit, but will suggest only such points as bear more immediately upon the question to be discussed, namely,

HOW DID THE SILVER GET INTO THE SANDSTONE?

Let it be remarked right here, however, that no one can pretend to furnish a complete solution of the problem in all of its details without a most minute and accurate knowledge of every detail of structure and relation presented by the deposit in place. Such a knowledge can rarely be acquired at second hand, nor can it be attained even by investigation in the field, until the mines have been much more thoroughly opened than is the case at the present time. These mines have been prospected to the depth of only — ft. The Comstock lode has been pierced to a vertical depth of nearly 3,000 ft., and scientific men are to-day unable to demonstrate precisely how the ore came into its present position, and where it came from.

The temptation to hasty generalization from insufficient data is, perhaps, nowhere so great as in geology. Instances without number can be cited where

THEORISTS HAVE FALLEN INTO ERROR

by drawing hasty conclusions from too few or imperfectly observed facts. I would prefer altogether to await the accumulation of observed facts and let them explain themselves, as they always will sooner or later, if properly recorded and collated. However, the average modern investigator in almost every department of science has found it necessary to have constantly in mind what he calls a "working hypothesis" concerning the subject under investigation, which is to him the most rational of the many explanations of the phenomena in question which suggest themselves. Since we must have these hypotheses, it behooves us (particularly where practical considerations of great moment are involved, as in mining) to see that our hypotheses rigidly conform to observed facts, and that, as soon as this is not the case, we discard them for less objectionable ones.

It is in this spirit that we approach the present question, fully aware that at this distance from the field, and with the few data in hand, a complete solution is impossible, but believing that at least a rational choice from the two or three proposed hypotheses can be made.

To return, then, from this digression to the facts of the case.

THE SILVER REEF MINES

are situated in extreme southern Utah. The sandstone containing the silver ore is of triassic age, as recently determined by Prof. Newberry. They are not to any extent metamorphosed from their primitive condition. There are two silver-bearing sandstone strata or "reefs," as they are called, overlying each other but separated by beds of clay shale. The ore, which above water line is mostly horn silver, and below it silver glance, is not homogeneously distributed through the entire rock, but is largely concentrated in ore channels, lying one above another in the different beds. Organic remains of plants, partially or wholly converted into ore, are very plentiful; they make up, perhaps, the bulk of the ore, although it is distinctly stated by Mr. Rolker "that he had mined portions of these beds for a stretch of 200 consecutive ft., which were absolutely devoid to the eye of organic remains, and yet yielded an average of $30 per ton.

On the other hand, organic remains are plentiful in sandstone layers quite free from ore, but overlaid and underlaid by sandstone free from fossils and full of good ore. Mr. Rolker also cites another instructive instance of a layer of 2 ft., of $30 sandstone, which itself lies upon 15 inches of barren rock, under which the sandstone again carries $30 ore.

Further, at Silver Reef comparatively little copper is found, while farther south copper enters largely into the ore, and in the same triassic sandstone on the west flank of the Nacimiento Mountains in New Mexico, the silver gives place entirely to copper.

Prof. Newberry finds that the extension of these sandstones into the table lands to the east of Silver Reef, and along Cedar Mountains as far north as Beaver, all contain silver, though rarely more than seven or eight ounces per ton.

Finally, in the words of Mr. Rolker, "the Silver Reefs are, where the silver is mostly concentrated, in close proximity to former volcanic centers; as is likewise the case at another less known locality, viz., at Virginia City on North Creek."

These, then, are the facts which we have to interpret. How did the silver get into the sandstone?

SEVERAL THEORIES

have been propounded. Prof. Newberry thinks that "the silver, like the copper which the sandstones contain, was deposited with them, and not introduced subsequently."

Mr. Cazin, of New York, takes exception to this, and thinks that "the ore deposits both of copper and silver in the triassic sand-rocks are precipitations from solutions containing metals, upon animal and vegetable matter, such matter, and not the metallic ores, being contemporaneous with the deposition of the sandstone." This is really, however, one of the possible interpretations which can be given to Prof. Newberry's statement of the case.

The usually accepted theory is that the metal solutions come from below, and are dependent upon and immediately subsequent to the eruption of igneous rocks in the vicinity of the present deposits. The hot springs bringing the metal solutions are the last dying manifestations of subterranean activity.

Let us examine these theories in the order indicated.

It is unfortunate that Prof. Newberry's opinion is not couched in specific language. It was probably not intended as a scientific statement, as it was contained in a personal letter to the President of the Stormont Mining Company, published in the *Engineering and Mining Journal* of October 23, 1880. It is susceptible of two or three quite different interpretations, possessing in common only the fact of contemporaneousness of deposition of the inclosing sandstones. I will give, first, the most natural one, and the one which I think he intended, viz., that the ores were precipitated out from solution in the ocean, at the bottom of which the sandstones were formed. The only ground for this view given by Prof. Newberry is his discovery of copper and silver in the same triassic sandstones in the table lands to the east and as far north as Beaver.

Now, on the one hand, this comparatively widespread impregnation can be equally well explained by another theory, while on the other hand the theory itself seems to be unable to explain already observed facts. Conceding for the moment that the theory is the true one, there are two ways by which this precipitation could be effected, viz., by separation caused by over concentration of the triassic ocean, or by reduction out of a far less concentrated solution by means of organic matter.

I find it hard to believe that Prof. Newberry would have us accept the first method. It would be like asking us to believe that the Pacific Ocean, or any considerable area thereof, was made up of a concentrated solution of blue vitriol.

Mr. Rolker urges against this view that it would necessitate the existence at the present time of a homogeneous mechanical impregnation of the entire triassic sandstone covering hundreds of square miles in Utah, New Mexico, and Colorado, while, as a fact, we find the most of the ore locally segregated, and but a small amount at distances removed from these local segregations. This objection is not a valid one, as it is quite possible for the local segregation to have been entirely subsequent to the original deposition of the ore and sandstones. One certainly could not explain, upon this hypothesis, however, the peculiar form in which this local concentration is at present found, viz., in ore channels lying over each other in the two beds.

It is likewise difficult to conceive how the alternation of sandstone layers, rich in silver, poor in silver, and free from silver, as described above, could be explained upon this hypothesis. We should have to suppose the superincumbent ocean to be alternately exhausted and resupplied several times, or else, that later, the ore in the now barren sandstone was leached out and concentrated in the next lower bed. The first supposition is, to say the least, a strained one; and as for the second, there certainly appears to be no good reason why such a leaching process, if it took place at all, should favor narrow zones of but fifteen inches thickness, and not be general over the entire sandstone bed.

Again, there seems to be no adequate relation between the amount of ore existing in the sandstones and the amount of copper and silver salts required to saturate an ocean to the point of deposition.

Finally, the fact that the Silver Reef region contains almost exclusively silver ores, while farther south it becomes largely replaced by copper, and again still farther to the southeast, in the triassic sandstone of the Nacimiento Mountains, in New Mexico, the silver gives place entirely to the copper, seems to me fatal to the hypothesis. I do not see how a subsequent separation of copper from silver over such an extensive area could be brought about.

Without denying, however, that in the progress of chemical geology the chemical possibility may be established, it must at least be acknowledged that at the present day it looks like an arbitrary assumption.

The second method of deposition above indicated, viz.,

REDUCTION BY ORGANIC MATTER,

out of a sea very far below the point of saturation, is an altogether more rational assumption. We are quite prepared to

* Supplement 279 will contain a description of a simple and inexpensive Holtz machine, and numerous additional experiments. Supplement 280 will contain working drawings of a single and double plate Holtz machine, and will treat on the curative applications of static electricity.

believe that a minute proportion of silver existed in the waters of the triassic ocean, inasmuch as it appears highly probable, although not yet directly proven, that copper and silver exist in the sea water of the present ocean in exceedingly minute quantity.

Now, while organic matter would unquestionably reduce the ore even from exceedingly dilute solution, my principal objection to this view of the question is, that in an ocean made up of such a dilute solution, there would be even far less probability that most of the copper would be reduced in one portion of the sea bed, as at the Nacimiento Mountains, while most of the silver was deposited in a different portion of the same sea as at Silver Reef.

Ocean currents would certainly bring about a comparatively homogeneous composition to the whole body of water necessitating a chemically homogeneous impregnation of copper and silver over the entire triassic area; and as I have said before, I do not see how the copper and silver could subsequently become differentiated. But again, conceding this to be possible, neither of these theories would explain why the ores in the two or three principal localities (Silver Reef and Virgin City, Utah, and on the west flank of the Nacimiento Mountains, in New Mexico) should become concentrated in the vicinity of eruptive rocks, and, so far as we yet know, there only.

Mr. Cazin advocates essentially this theory of reduction by organic matter out of an ocean containing an exceedingly small amount of copper and silver. He modifies it, however, by assuming that the deposition of the organic matter only was contemporaneous with the formation of the sandstones, which organic matter became gradually converted in ore by exposure during thousands of years to the waters of the superincumbent ocean percolating downward through the subsequently formed and forming sandstone.

The theory even thus modified is open, however, to all of the objections above stated.

The only remaining interpolation that can be given to Prof. Newberry's language (and this, in my estimation, is the most plausible of all) is, that the ore particles are the result of the

MECHANICAL DISINTEGRATION OF PRE-EXISTING ORE DEPOSITS,

just as the grains of quartz in the sandstones are the result of the mechanical disintegration of pre-existing silicious rocks, or that the ore grains thus originally formed by mechanical disintegration became subsequently oxidized into sulphates, and again reduced to sulphides by the organic matter in the sandstones.

A fatal objection to the first process (as indicated by Cazin) is that the difference in specific gravity between the ore grains and the sand grains would inevitably lead to the mechanical segregation of the ore, in comparatively restricted areas. Furthermore, the ore particles are not rounded or water worn, but have evidently been formed just where they are now found, proven also by the plant remains converted into ore, which would not bear transportation and preserve their form.

The second process, viz.: Oxidation to sulphate and subsequent reduction by organic matter, would obviate the objection that the ore particles are not rounded, but would certainly not that founded upon differences of S. G., although such a process would certainly admit of a far more extensive impregnation of the sandstone than the purely mechanical theory.

Further, we have the testimony of Mr. Rolker, that the mountains in the immediate vicinity of these deposits have as yet revealed no ore bodies to the industrious prospector, while the nearest vein deposits situated to the north, contain gold and lead with the silver. Rolker pertinently asks if the ores are derived from this source, why do we not find lead or gold with the silver in the sandstones?

Finally, neither of these theories explains the occurrence of the ore in channels previously described, nor the concentration in the neighborhood of eruptive rocks.

There being, then, valid objections to all of the theories thus far suggested, let us turn to the last and most generally accepted theory, viz.: That the

METALLIC SOLUTION CAME FROM BELOW,

and were dependent upon and immediately subsequent to the eruption of the igneous rocks in the neighborhood of the present deposit.

In the first place, let it be noted that this is substantially the theory ordinarily accepted for the formation of true fissure veins, so that if it can be made equally applicable to such deposits as these under consideration, there would be a certain amount of presumption in its favor even if other things were equal. As fast as an hypothesis becomes gratuitious in science, it is eliminated—it becomes unnecessary. Not that nature always produces the same effects in precisely the same way. Too close adherence to this idea has frequently led into error. The only safe test is for each specific case to bring our theories to the ordeal of a satisfactory explanation of observed facts. In the present instance I fail to see a single fact which cannot be explained upon this hypothesis.

In the first place the igneous rocks are in close proximity to every locality where ore in paying quantities has been discovered.

It explains the occurrence of the ore in chutes or ore channels, one above another in different beds. The eruption of igneous rocks could not fail to fissure more or less the adjacent sedimentary rocks. The solutions which followed, bringing the silver and copper, would come through these fissures, and would, of course, deposit the greater portion of their metallic contents in and near the fissures which now form the ore channels. It would explain the alternation of rich and barren zones in the sandstone. We know that solutions will travel in channels offering the least resistance. The layers richest in ore will be such channels, and in proportion as the physical or chemical conditions for absorption are unfavorable in the same proportion will the rock be poorer in ore.

It would explain the preponderance of silver in one portion of the triassic sandstone, and of copper in another portion, viz., they came through different fissures and from different sources below.

It would explain the impregnation of the sandstones even at considerable distances from the larger bodies of ore. I have already cited the common occurrence of lateral impregnation of the country rock on either side of fissure veins. In the same way from the main channels in the sandstone the lateral impregnation of the body of the rock, even to considerable distances, would take place.

Mr. Cazin objects to this theory (and considers the objection fatal) that the ore deposits are not local, but extend over Utah, New Mexico, etc., and hence they cannot be dependent upon local fissures; and, furthermore, that it is characteristic of the triassic sandstone that it is not fissured.

In reply I would say that, if the ore deposits are not local, neither are the igneous rocks local; and that according to Mr. Rolker the two go together—*i. e.*, the larger or more pronounced concentrations are in the neighborhood of crystalline rocks. In the second place, I am compelled, on general principles, to doubt Mr. Cazin's statement concerning the absence of these fissures over such an extensive district. The greater portion of the jura triassic area between Leeds district, Utah, and the Nacimiento Mountains, New Mexico, is deeply covered by later sedimentary rocks, exposed only in places in the deep cañons of the rivers which drain the country. Even these exposures have not all been investigated to prove either the presence or absence of silver or copper ores. One cannot speak, therefore, of an universal impregnation of the entire triassic sandstone, nor of the absence of fissures over that whole area.

Finally, concerning the existence of fissures in those places which have been explored, neither Prof. Newberry nor Mr. Cazin recognized any fissures; but Mr. Rolker has discovered the key to the whole problem when he recognized the

EXISTENCE OF THE ORE CHANNELS

at the Stormont Mine, and properly explains them, viz.: During the disturbances attendant upon the eruption of the neighboring igneous rocks, the sandstones were fractured without opening. Instead of producing open fissures to be subsequently filled like ordinary fissure veins, the result was the formation of cracks, along which, from the friable nature of the sandstones, the rock would be considerably crushed, and might, later, partially heal up. But the ultimate result would be the existence of numerous

VERTICAL CHANNELS OR WATER-WAYS,

which would certainly be followed by metal solutions forcing their way upward. These water-ways would finally contain the largest amount of ore, and would form the ore channels which Mr. Rolker describes, and from them the lateral impregnation of the sandstones, even to considerable distances, would be easily effected.

These water-ways would branch and ramify through the rock in all directions, never making themselves visible on the surface as fissure veins, and, in fact, by the entire absence of all the usual characteristics of fissure veins, such as distinct walls, selvages, etc., would easily escape the observation of even such an acute observer as Prof. Newberry.

It is, then, by such a process as this that I would explain the wide-spread impregnation of the sandstone, so far as yet observed, and the apparent absence of fissures, as insisted upon by those who have written upon the subject.

The silver came into the sandstones, consequently, in the same general way that the silver came into the Comstock lode, or any other fissure vein, the present difference in the mode of occurrence being due to the fact that the fissures did not open, and that the sandstone absorbed the metallic solutions like a sponge, as fast as they came in contact with it.

GENERAL CONSIDERATIONS.

The existence of water-ways was first suggested to me by a large and magnificent specimen of ore from the Bassick mine, in Colorado, now in the Museum of Economic Geology of the University of California, presented about a year ago by Mr. J. B. Farish, of Silver Cliff, California. The country rock of the Bassick mine is an igneous rock (sanidin trachyte), and the difference between their modes of occurrence at this mine and the Silver Reef mines is due entirely to the different nature of the country rocks. The trachyte exists in the form of irregular fragments, from the size of a walnut to many feet in diameter, all more or less rounded and greatly decomposed by the action of infiltrating metallic solution which have deposited the ore between the fragments. Had the rock been anywhere nearly as porous as sandstone, we should have found here the same extensive lateral impregnation as at Silver Reef.

A subsequent visit to the Sulphur Bank quicksilver deposit, in Lake County, California, disclosed precisely similar relations at that mine. There augite andesite, which forms the bank, has been irregularly fissured at the time of its original solidifications, and subsequently infiltrated with metal solutions carrying mostly quicksilver ore.

I have learned recently from Prof. Joseph Le Conte that this idea of the widespread occurrence of water-ways has been suggested by him in his lectures on geology for the past two years, and that in the next edition of his geology he proposes to give it prominent place.

We are both convinced of the value of the suggestion. In fact, it is only by means of it that many otherwise puzzling deposits can be understood. It brings likewise into close genetic relation a large number of ore deposits which pass in the literature as impregnations, stocks, veins of substitution, irregular deposits, geyser deposits, etc.—into genetic relation, not only with each other, but with what must be regarded as the simplest type of them all, viz., the fissure vein.

It is certainly to be expected, *a priori*, that the process of rock fracturing that accompanies every considerable disturbance in the mutual relations of rocks, for one fracture that is accompanied by the formation of an open fissure, many would be formed without opening, and through which metallic solutions could force their way upward. The form of the resulting deposit would then depend upon the nature of the rock in which the fracture was produced.

If the fissure opened, we should have the simple fissure vein; if it remains closed, and the rock was porous like sandstone, we should have, as at Silver Reef, ore channels with very extensive lateral impregnation of the surrounding rock; if the rock was not porous, like the Bassick and Sulphur Bank rocks, we should have comparatively thin veinlets ramifying in all directions, accompanied, as it always is, by extensive decomposition of the rock; if the rock is very easily acted upon chemically by the metallic solutions, as in the case of limestone, dolomite, etc., the softer portions would be dissolved, outforming huge caverns of most irregular form, which would subsequently become partially or wholly filled with ore, as at the Eureka and Richmond Consolidated Mines, in Nevada.

The ore deposits at Silver Reef and at the Nacimiento Mountains are by no means the first sedimentary rocks containing sulphureted ores, which have been discovered. These beds are the first that have yielded any considerable amount of silver; but copper, lead, and quicksilver, and even gold, have long been known in similar beds. I will mention but one or two localities; thus, at Vorospatak, in the Siebenburgen Mountains, the Carpathian sandstones are impregnated with gold and quartz; at Bleiberg, in Carinthia, galena is found in limestone; at Bohmisch-Brod and Schwarzkosteletz, in Bohemia, the sandstone of the Rothleigenden formation of the Germans is impregnated with copper ores. The copper schist of Mansfield, at the base of the Harz Mountains, is another instance, and many more might be mentioned.

I have studied carefully the geological relations of many such deposits, to see which of the above-mentioned theories best explained the recorded facts. The theory which best explains the phenomena at Silver Reef is likewise the one which appears most rational for most of the others. With but a single exception (Commern, near Aachen, in Rhenish Prussia), sedimentary rocks are impregnated only in the neighborhood of eruptive rocks. I will mention here but a single striking instance, the copper mines of eastern Russia. Central Russia is one vast, monotonous region of comparatively undisturbed sedimentary strata, perfectly free from sulphureted ores of all kinds. But as soon as we reach the extreme eastern edge, where the igneous masses of the Ural Mountains have forced their way upward through the sedimentary beds, there we find these same sedimentary rocks impregnated with ores of copper; while, in the immediately adjacent mountains, the same metal is abundantly present in the fissure veins of the eruptive rocks.

PROSPECTING IN SANDSTONE DISTRICTS.

One more point and I will close. It is the answer to the question I asked in my introduction: "Has the prospector any practical guide in his search for the precious metals?" I can only state what must still be considered as about the only law which is generally applicable to all mineral districts where the precious metals have thus far been mined, viz., that deposits of the precious metals occur almost exclusively in the neighborhood of the massive crystalline rocks.

Gold and silver may at any time be found in sandstones and similar sedimentary rocks, but only in the neighborhood of the massive crystalline rocks, and it is useless to prospect sedimentary rocks for the precious metals at great distances from such geological formations.

It is scarcely necessary to add that superficial drift deposits and all kinds of placer deposits, both recent and older, may form exceptions to the law as above stated.

A. W. JACKSON.

Museum of Economic Geology, University of California.—*Mining and Scientific Press.*

THE DIFFERENT QUALITIES OF IRON ORES.

By JACOB REESE, Metallurgical Engineer.

The different qualities of iron ores are due to the admixture of more or less foreign matter with the oxide of iron, or in the percentage of oxygen in the oxide of iron. There are two general classes of iron ores—the igneous and the hydrated ores. The igneous ore is found in the primitive formations, and was probably deposited there while in a molten condition. The hydrated ores are found in all formations, probably coming from a disintegration of the igneous ores, and carried by water to the place of their deposit. Igneous iron ores are generally embedded between two strata of rocks; the ore next to the rock does not contain much iron, as the rock has become admixed with it. The best ore of this class is found in the center of the bed, and the thicker the vein or deposit is, the better will be the ore, as a general thing.

The hydrated ores are not so rich in iron as the other class, as in their transit from their original igneous bed, if the water in which they were carried was impregnated with sulphuric acid or phosphoric acid, the ores when deposited will embody these compounds. If the water was impregnated with clay, sand, or lime, the ores deposited will be found to be aluminous, silicious, or calcareous.

When we find a pure peroxide iron ore, in the igneous bed, it contains 70 per cent. of iron and 30 per cent. of oxygen, and from such ore a blast furnace properly conducted will produce from 68 to 69 per cent. of pig metal; but peroxides are seldom found to be as pure as this. The average of a very good ore of this class is peroxide 95 per cent., and 5 per cent of other matter; now, 70 per cent of 95 will give 66½ per cent. of iron in the ore, and a good furnace in prime working order will yield 65 per cent. of pig metal from such ores. Some of these igneous ores contain 10 per cent. of foreign matter, and 90 per cent. of oxide of iron; this will give 63 per cent. of iron in the ore, and a blast furnace will not generally produce more than 60 per cent. of pig metal from such ores.

The hydrated ores contain from 5 to 50 per cent. of foreign matter, and in addition to the earthy material which is admixed with them, the ores also contain from 5 to 20 per cent. of water. Hematite is a hydrated ore, and seldom contains less than 10 per cent. of water. Now, a hematite which does not contain over 5 per cent. of earthy matter and 10 per cent. of water, will only yield 55 per cent. of metal from the furnace, while the igneous ore which contains the same amount of earthy matter will yield 65 per cent. of metal. And in addition to this, the water in the hematite requires coal to vaporize it. Just think if one of our Pittsburg furnaces was to be fed on hematite, which would require 3,000 tons of ore for each furnace per week; in this ore there would be 300 tons of water—of course the furnace would not be able to make as much metal—it would be like working the furnace on igneous ores, and running 300 tons of cold water into the tunnel head each week.

A few years ago, while examining the stock of a blast furnace, the proprietor showed me what he called a very fine hematite ore. I asked him how much water it contained, and I was surprised to hear him say: "None, except when it rains." But I found that he had no analysis of the ore, except for the amount of iron which it contained. He ordered a full analysis, and was astonished to learn that his dry-looking hematite contained 12½ per cent. of water, and he added in his letter to me: "What a fool I have been, paying $4.80 per ton for water, when the Mississippi runs full and free alongside of my furnace." But still it does pay to work the hydrated ores, when their low price will pay to fuse the extra earthy matter and boil the water out of them. However, it is important in determining their value to consider the amount of water which they contain, and the cost of extra fuel in vaporizing it.

Phosphorus cannot be separated from iron while it is in the presence of carbonic oxide or silicic acid; both of these are present in the blast furnace, hence all the phosphorus contained in the ores is found in the pig metal; and, therefore ores being high in phosphorus were called bad ores. But, happily, now we have discovered a practical method of securing the required chemical conditions by which we are enabled to eliminate the phosphorus from the metal as it flows from the blast furnace, or in the Bessemer converters, or in the open hearth. The means by which this is done is known as the basic process, and the time required is from two to five minutes to dephosphorize fifteen tons of metal. So that those phosphoretic ores which are rich in iron may now be put into basic dephosphorized pig metal, or into basic dephosphorized ingot iron or ingot steel.—*B., T., and M. Review.*

FITZJOHN TOWER, HAMPSTEAD.

THIS house is now being completed, from the designs of Mr. John Thomas Wimperis, of 25 Sackville street, Piccadilly, for Mr. Herbert F. Baxter. A domestic mediæval style has been adopted, admitting of much variety of treatment, and is executed in red brick, with black pointing, Portland stone dressing, Broseley tile roofs, ornamental crestings and terminals, with wrought-iron finials to tower, partly gilded. The builder is Mr. William Brass, of Old street, St. Luke's.—*Building News.*

THE CUNARD STEAMSHIP SERVIA.

THE rapidity with which the dimensions of vessels built for the mercantile service have increased in recent years has been remarkable, and such as to outstrip all former conceptions as to size and driving power. Within the past two or three years Messrs. Elder & Co., of Glasgow, constructed the Arizona, 5,147 tons and 1,200 horse power; the Orient, 5,386 tons; and the Austral, 5,500 tons, the two latter for the Orient line; and likewise the Alaska, for the Guion line, 6,350 tons. The City of Berlin, built by another firm, has a tonnage of 5,491, her length being 488 ft. Each of these vessels was regarded at the time she was put into the water as exceedingly large; but they are left far behind by the Servia, which was launched recently from the shipbuilding yard of Messrs. James & George Thomson, Clyde Bank, Glasgow. The Servia has been constructed to the order of the Cunard Company (Limited) for their royal mail service between Liverpool and the United States. Our readers will recollect that a short time ago the Messrs. Thomson built a large and remarkably fine vessel, named the Gallia, for the Cunard line. The Servia is constructed of steel, but is of much greater dimensions. As regards length and tonnage, she exceeds all other merchant ships hitherto built, while in the matter of engine power she will surpass anything afloat. The dimensions of the Servia are: Length over all, 530 ft.; breadth, 52 ft.; depth, 49 ft.; and tonnage, 8,500. She is constructed with a double bottom, on the longitudinal bracket system, and she will carry 1,000 tons of water ballast. Her cargo capacity will be 6,500 tons, with 1,800 tons of coal. The machinery consists of three cylinder compound-surface-condensing engines, one cylinder being 72 in. and the other two each 100 in. in diameter, with a stroke of piston of 6 ft. 6 in., and it is anticipated that the indicated horse power will be 10,500. Steam will be furnished by seven boilers, one single and six double ended, all made of steel, with corrugated furnaces thirty-nine in number. The weight of the propeller shaft is 26½ tons, and the propeller, boss, and blades, which are made of Vickers' steel, weigh 38 tons. It may further be stated here that the anchor davits are 8 in., and the chain-cable pipe 22 in., in diameter. The Servia is, to all intents and purposes, a five-decker, having four decks and a promenade, the latter, which is reserved for the passengers, being very large and spacious. The forepart of the promenade contains the steam steering gear, captain's room, and flying bridge. On the upper deck, forward, is the forecastle, while behind are the light towers, for signaling. The captain's and officers' sleeping apartments adjoin the midship house, and next to the engine skylight there is a smoking room, 30 ft. long by 22 ft. wide, which can be entered either from the deck-house or the cabins below. Near the afterdeck-house is the ladies' drawing room, a magnificent apartment, with access from the deck, and also leading abaft into the music room, the dimensions of which are 50 ft. by 22 ft. Behind the music room is the grand staircase, leading to the main saloon and the cabins below on the main and lower decks. The great saloon is 74 ft. long and 49 ft. wide, leaving a clear height under beams of 8 ft. 6 in., and it affords sitting accommodation for 350 persons. The paneling and upholstery of the saloon, and, indeed, of all the apartments, are very fine. There are 58 staterooms in the vessel, and accommodation for 450 first-class and 600 steerage passengers, besides a crew of 200 officers and men. The ship will carry twelve fully equipped lifeboats. Built, according to the Admiralty requirements, for war purposes, the Servia is divided into nine water-tight portions, a special feature being the arrangement of the water-tight doors, which, in case of accident, can be shut from the upper deck in a few seconds. All the frames and beams of the ship have been riveted by Twedell's hydraulic riveter, as was also the keel, which consists of five thicknesses, the total thickness being 6¾ in. Three of the decks are of steel, the upper covered with yellow pine and the second and lower decks with teak. To give them the power of resisting heavy seas all the deck-houses and fittings are of iron, and strongly riveted to the steel decks beneath. The Servia has three masts, which will carry a good spread of canvas. Great attention will be paid to her furnishings, and she will be provided with the newest and best appliances for steering, ventilation, heating, and other purposes.

We are glad to see that the value of ample pumping power is now fully recognized by the owners of our great steamship lines. The Servia is fitted with three of Messrs. John & Henry Gwynne's direct-acting centrifugal pumping engines, two of which are capable of discharging 11,000 gallons of water per minute each; one of them is sufficient to circulate the water in the condenser, the other being held in reserve. They are so arranged that either engine may work either pump, or quite independently of each other, as circumstances require; if necessary, both engines can pump from the bilge. The third pumping engine will do the ordinary work of the ship and pump from the ballast tanks and bilge; it is capable of discharging 1,800 gallons of water per minute to a height of 40 ft. All the Cunard steamers, it may be noted, are fitted with Gwynne's pumping engines in a similar manner. The Garth Castle and the Drummond Castle, of Donald Currie & Co.'s line, recently launched, are also fitted with them.

It may be of interest to state that, including the Servia, the Cunard Company have at present 30,000 tons of shipping in course of construction on the Clyde. Messrs. Thomson are building the Aurania, 7,000 tons, and the Pavonia, 5,000 tons, for the Cunard line; and Messrs. Barclay, Curle & Co., of Glasgow, are building the Alligator, Dromedary, and Gorilla, and Messrs. Blackwood & Gordon, of Port Glasgow, the Lizard and Locust, for the Belfast line.

The launch was witnessed by an immense concourse of spectators, special trains having been run by the North British Railway Company, and three river steamers having also gone down to Clyde Bank with passengers. As the vessel glided majestically into the water, having been christened Servia by Mrs. Burns, wife of the chairman of the Cunard Company, there were loud and hearty rounds of cheers. After the launch, a large and distinguished company of ladies and gentlemen were entertained at luncheon by Messrs. J. & G. Thomson, the builders, in the model room at Clyde Bank. The loyal and patriotic toasts having been given and responded to, the chairman proposed success to the Servia, coupled with the name of Mr. John Burns, who replied. There was, he said, a great gulf between the Britannia, which started on her first voyage more than forty years ago, and the Servia, and the comparison showed the prodigious steps that had been taken in marine architecture. The Britannia measured 1,139 tons, with a cargo capacity of 225 tons, and steamed 8¼ knots an hour, whereas the Servia measured 8,500 tons, and would attain, it was believed, a speed of 17½ knots an hour. The Earl of Ravensworth, in proposing the health of the builders, said the Clyde was a name that was in everybody's mouth in every part of the world. The Clyde had always been celebrated, and was now at the head of the shipbuilding enterprise, and he thought that every citizen of Glasgow should feel proud of the additional laurel gained that day by the enterprising firm whose health he proposed. The chairman acknowledged the compliment, and various other toasts being honored, the company separated.—*The Engineer.*

THE WORK OF PROPELLER WHEELS.

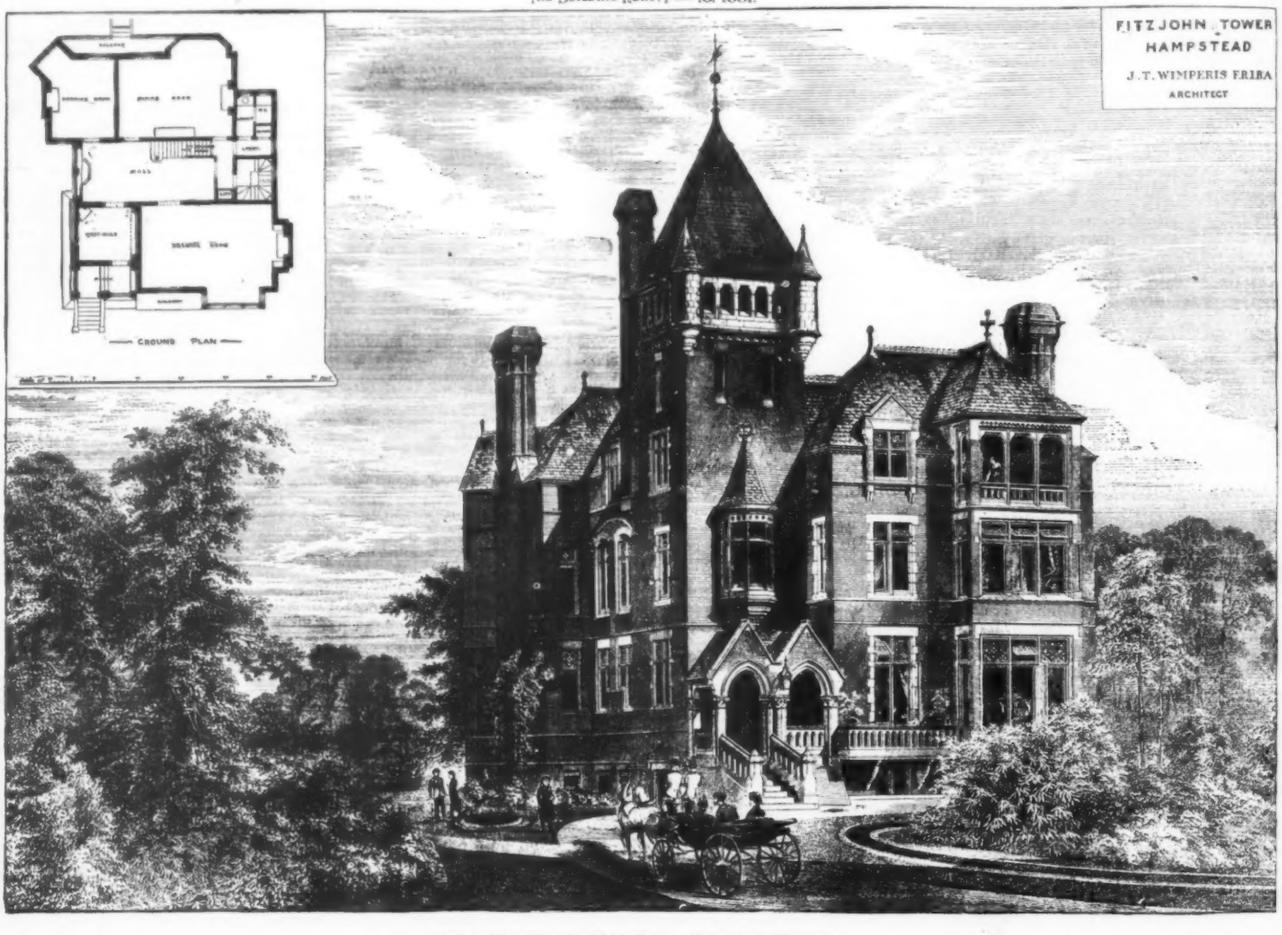
By H. C. PEARSONS, U. S. Inspector of Steam Vessels.

To the Editor of the Scientific American:

In view of the great interest shown in your journals for "screw propulsion," I send you the following analysis of the work of propeller wheels, together with some notes on the "lead" of wheels.

In the opposite plate, Fig. 1 represents a portion of the projected area of a propeller wheel, divided into concen-

THE BUILDING NEWS, FEB. 18, 1881.



FITZJOHN TOWER, HAMPSTEAD.

metric rings of uniform width, and numbered consecutively from the center outward.

In Figs. 2, 3, and 4, the length of the parallelogram, E, O, F, I, is the developed circumference of the wheel, while the breadth, O, F, is the lead, expressed in terms of the diameter as unity; and each parallelogram is subdivided into a number of other parallelograms, equal to the number of rings in Fig. 1, by the full vertical lines—each of the smaller parallelograms being numbered at the top, the same as the ring with which it corresponds, so that the width of each of the small parallelograms is the developed circumference of a circle, whose radius is the width of one of the rings, as given in Fig. 1.

From the center of the foot of each of these secondary parallelograms, a line is drawn to F. These oblique lines are the developed helices of the center lines of the rings to which they correspond. Thus, 15, F, is the developed helix corresponding to the middle of the outer ring, No. 8, etc., and F, 15, O is the corresponding angle of lead.

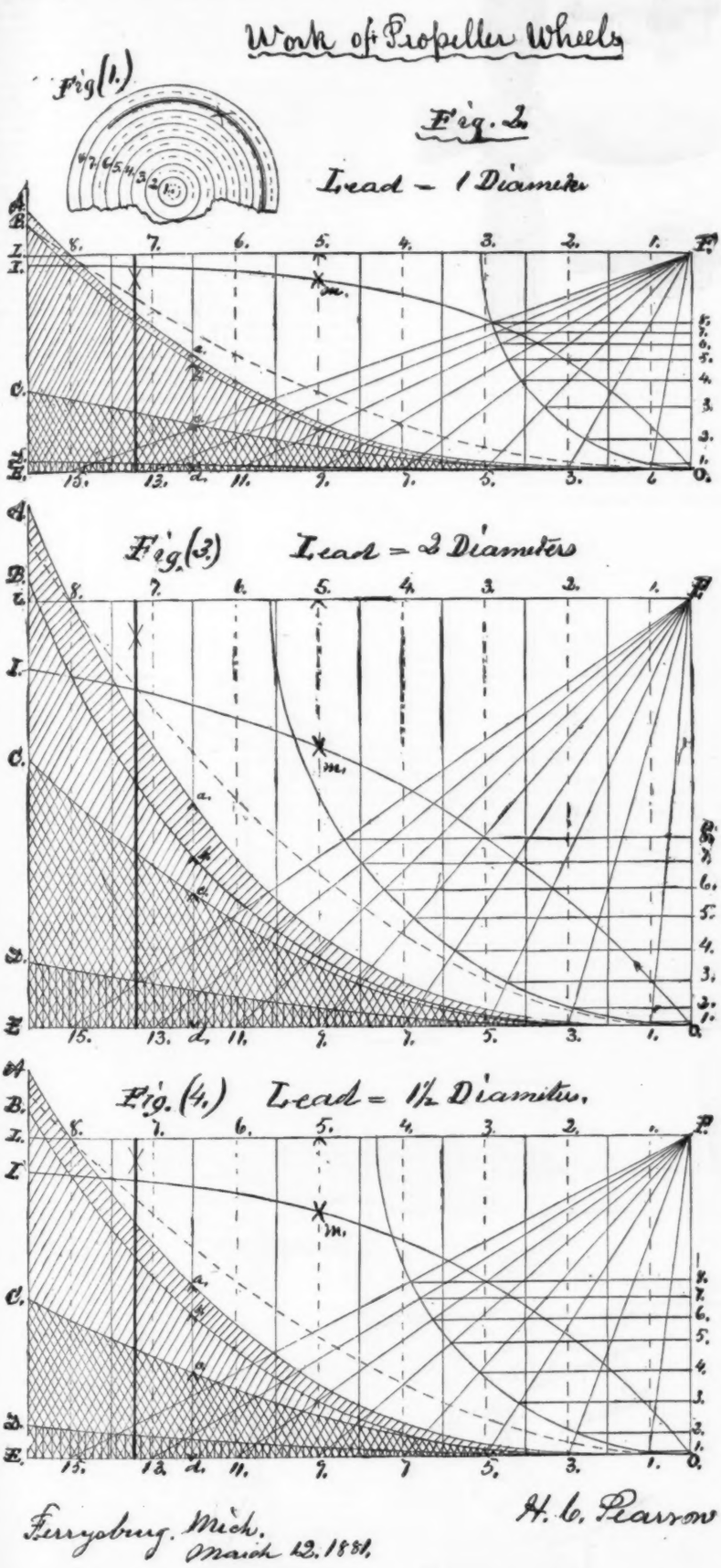
The work of the propeller blade being applied at right angles to the surface, the *useful* work of any ring is measured by the cosine of its lead angle, while the lost work is measured by the versed sine of the same angle. These cosines are constructed in the right hand of each figure, on a radius equal to the lead regarded as unity, and set up on their respective or corresponding perpendiculars; thus, the cosine, No. 8, is set up on the dotted line, 15, 8; cosine No. 4, is set up on 7, 4, from E, O, etc.; and the curve, I O, drawn through the upper extremities of these cosines, shows how much of the work that is applied to each ring is utilized; while the complements of these cosines show the amount of power lost in each ring; thus, of the total power applied to

ring No 5, the ordinate, M 9, in each of the several figures shows how much is utilized, while the versed sine or complement, M 5, of this ordinate, shows the amount lost.

Because of the angular motion of the wheel, points near the circumference travel faster than those near the center—the velocity increasing as the diameter or as the circumference.

Moreover, the intensity of percussion or impact of the surface of the wheel with the water varies as the square of the velocity, or as the square of the circumference; whence, representing the work of the outer ring by unity, and drawing through 8 O the curve of a parabola, with vertex at O, we shall have a curve whose ordinates will represent the *relative intensity* of the work in the several rings; for it is a property of this curve that the ordinates vary as the square of the tangents; the broken line in the several figures is this curve.

Again, because the area of the wheel varies as the square of the diameter, or as the square of the circumference, and because, as has just been seen, the intensity of work at different points in the radius of the wheel varies by the same ratio, the total work done at different points on the radius varies as the *fourth power* of the circumference. Whence, if we regard the total work done by the outer ring as unity, and construct a curve through 8 O, such that the ordinates vary as the *third power* of the distances on the tangent, E O, then the total area embraced between the curve, the ordinate (external secant), and the tangent, will vary as the *fourth power* of the corresponding tangent (circumference), and represent the total work done within such circumference; thus, the area between the curve, A O, the tangent, E O, and the ordinate (external secant), E A, represents the total work—useful and non-useful—done by the wheel, and is sixteen times as great as the work done within the first half of the radius, which is represented by the area embraced within the curve, the tangent, and the full line between the broken lines, 7, 4 and 9, 5. The ordinates of this curve are found by multiplying the ordinates of the parabola into the areas of the helicoidal rings; but these areas vary as their corresponding circumferences, so that the ordinates of this curve vary as the third power of the distances on E O, as above stated.


Work of Propeller Wheels
Fig. (1.)
Fig. 2.
Lead = 1 Diameter
Fig. (3.) Lead = 2 Diameters
Fig. (4.) Lead = 1½ Diameter.
Ferrysburg, Mich. March 12, 1881.
H. C. Pearson

It will be remembered that the ordinates of the curve, I O show how much of the work applied to any ring is utilized in that ring. Then as the ordinates of the curve, A O, show the corresponding total work for any ring, the product of the ordinates of these two curves, for any ring, will show the *useful work* for that ring; and the *total useful work* of the entire wheel is represented by the area within the tangent, E O, the ordinate, E B, and the curve, B O; and the area between the two curves, B O and A O, represents the *work lost* by oblique action.

In the same manner, by multiplying the ordinates of the curve, A O, by the sines of the lead angles, for each of the several rings, we have the ordinates of the curve, C O, whose area represents that part of the total work that is resolved into lateral effort.

This loss is analogous to back pressure in a steam cylinder, or backwater on a waterwheel.

A check on the accuracy of our work is found in the following relation of the ordinates, viz.: "In any of the secondary parallelograms the square of the ordinate of the curve, A O, equals the sum of the squares of the corresponding ordinates of the other two curves, B O and C O; thus $(a\ d)^2 = (b\ d)^2 + (c\ a)^2$."

It should be observed that this loss in lateral effort is not sustained fully, only when the vessel is made fast, as at a dock. On being released this loss vanishes, except so much as corresponds with the ship, which is much more in wheels of high lead than in those of smaller lead. In Fig. 2 I have drawn the curve, D O, to cut off twelve per cent. of this area; in Fig. 3 it cuts off twenty-five, and in Fig. 4 it cuts off twenty per cent., which is about the rate of slip for wheels of the lead specified; that is, the area cut off by the curve, D O, represents the *loss from lateral effort* when the vessel is free to go ahead; and I have drawn these figures with different leads, to show *how fast we lose power*, both by oblique application of power, and by lateral effort, when we increase the lead above that due to one, or about one diameter, which lead gives a maximum effect.

It is readily seen that the greater portion of work, both useful and non-useful, is well out toward the circumference of the wheel. The center of effort is marked by the thick line in the several figures; and regarding radius as unity, its distance from the center is the fourth root of ½ or $\sqrt[4]{\cdot 50} = 0{\cdot}84$, instead of the second root of ½ or $\sqrt{\cdot 50} = 0{\cdot}70$ as some authors tell us. This mistake comes from forgetting that the wheel has an angular motion.

From the above considerations it is easy to interpret the results of the experiments given on page 3806 of the SCIENTIFIC AMERICAN SUPPLEMENT.

In No. 1 the failure resulted from having *too much* of the efficient part of the blade cut away at the extremity, thereby throwing an undue portion of the work on to the interior part of the blade where the lead is greater, and where, consequently, a greater per cent. of loss of power was sustained.

In No. 2 the failure, though not so bad, results from the same cause.

In No. 8 the failure results from both causes—too little blade area at the extremity and too high angle of lead.

It may be remarked that this does not agree with the idea of Mr. Griffith in reducing the width of his screw blades at the extremity. It should be remembered that our losses are sustained, chiefly, at the extremity of the blade, and that, hitherto, it has been customary to make wheels much longer than at present, so that Mr. Griffith's problem was to cut away as much of the extremity of the blade as possible, without impairing the efficiency of the wheel. He could still improve his wheel by cutting away the width of the interior part of the blade, for we have shown that but little work is done there.

But, of all the questions that have been raised concerning the propeller wheel, perhaps there is none about which there is more diversity of opinion, uncertainty, and "fog," than that concerning the lead.

The "manuals" tell us that this element is a function of the relation between the projected area of the wheel, and the immersed transverse midship section of the vessel; and that it varies with the ratio of the former to the latter; in other words, the larger the wheel, compared with the immersed cross section of the vessel, the larger must be the lead.

The absurdity of this idea will be seen when we remember that by the best engineers the diameter of the wheel is determined by the draught of water to be had, making the wheel as large as possible, without getting it out of the water, and without reference at all to the amount of power at our disposal.

The practice of some of the best European engineers approximates that of making the lead to vary in an inverse ratio with the amount of work to be done by a unit of the projected area of the wheel. Thus, wheels required to work off 4 to 6 or 7 indicated horse power per circular foot of the projected wheel area, would have a lead 1·30 to 1·10 diameters; while those required to work off 10 to 17 indicated horse power per foot, would have a lead as near that of maximum efficiency, viz., 1 to 0·95, of the diameter as possible.

Maudsly Sons & Field make wheels of the latter class; and the ratio between their areas and the immersed cross section areas of their respective vessels is such that, if determined by the rules of the "manuals," from what they call the "relative resistance," the lead would be about *two diameters*.

This mistake comes from attempting to make the lead depend on the relation between the area of the wheel, and that of the immersed cross section area of the vessel, without at the same time making the size of the wheel to depend on the amount of power at our disposal.

Ferrysburg, Mich., March, 1881.

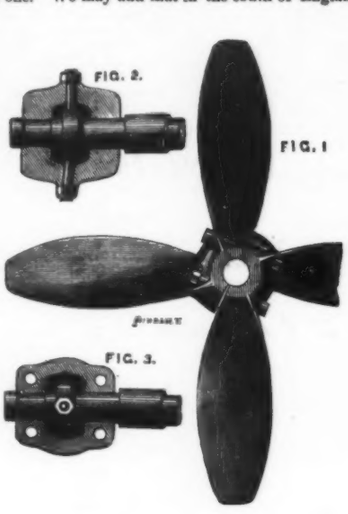
PLATTSMOUTH BRIDGE.

IN the article on Plattsmouth Bridge in the SUPPLEMENT of March 12, under one of the illustrations, the name of John C. Goodridge, Jr., is given as engineer of the foundations instead of contractor, as it should have been. Mr. Geo. S. Morrison was the engineer of the whole construction, as is stated in the text.

A NEW EXPERIMENT ON MAGNETIC ATTRACTION.—By E. PIAZZOLI.—The author shows that the attraction of elder pith by the magnet, as observed by Ader, depends probably on the presence of small particles of iron.—*N. Cim.*

IMPROVED SCREW PROPELLER.

WE subjoin an illustration of the "split boss" screw propeller lately patented by Messrs. Cooke & Mylchreest. The invention is a very simple one, and, considering the inconvenience attending it, it is singular that it should not have been introduced earlier. The essential feature consists simply in making the propeller in two halves, which are bolted together so as to clip the shaft. Referring to the engravings, it will be seen that in the propeller shown by Fig. 1 the two parts are simply held together by four bolts, while Figs. 2 and 3 show a modified arrangement specially suitable for propellers of large size. In the case of large propellers it would be inconvenient that both halves should be set free from the shaft together on removal of the connecting bolts, and to get over this a ring bolt, A, is provided, in addition to the four main bolts already mentioned. The center part of this ring bolt is a good fit on the shaft, but is not keyed to the latter or fixed in any way, while the ends are each screwed for a nut. It will be seen that by means of this ring bolt the two parts of the propeller will be held on the shaft after the main bolts have been removed, and each part can be taken off separately at pleasure. There is, of course, no occasion to make the shaft tapered where it fits the screw; but it is collared at the end, and this prevents the screw from working back or off the shaft. In a propeller 14 feet 6 inches in diameter, with four blades, which the patentees have now in hand, they are producing four main bolts, each 4¾ inches in diameter, and a ring bolt with ends 3½ inches in diameter, so that a very strong connection is obtained, the intention being to provide a connection with a strength materially in excess of that of the propeller itself at the roots of the blades. As regards any tendency of the nuts to slack back, it may be said that there is no more reason to anticipate trouble from this cause than in the case of ordinary propellers with blades bolted to the boss. The two halves of Messrs. Cooke & Mylchreest's propeller are, of course, much more convenient for stowage than an ordinary spare propeller, and altogether the arrangement promises to be a very useful one. We may add that in the south of England this



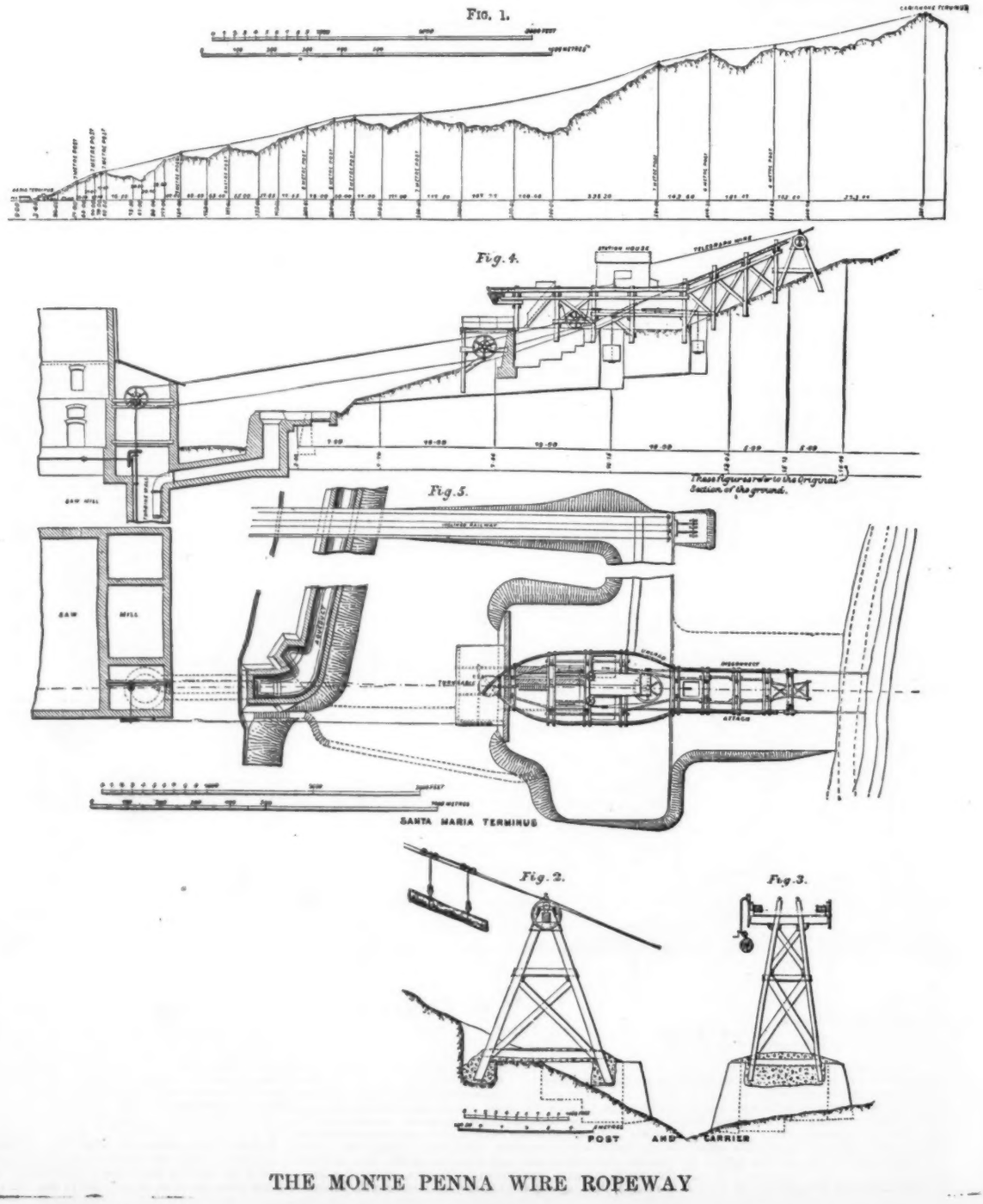
propeller is being introduced by Mr. John Hayes, of 27 Leadenhall street, London, E. C.—*Engineering.*

THE MONTE PENNA WIRE ROPEWAY.

WE reproduce, from the Transactions of the Institution of Civil Engineers, a paper contributed by Mr. W. P. Churchward, on "The Monte Penna Wire Ropeway." This line was constructed for the Monte Penna Forest Company, Limited, which possesses an extensive portion of beechwood forest land surrounding the Monte Penna, one of the highest points of the Apennines, 30 kilometers N.N.E. of the town of Chiavari, Italy. Its object is to convey timber and other produce, as charcoal, etc., from a point at the base of the forest to the small village of Santa Maria del Taro, at which place the company has erected a sawmill and other works. Communication between Santa Maria and Chiavari is opened by road.

The ropeway was constructed by Mr. Churchward from the designs of Mr. W. T. H. Carrington, Assoc. M. Inst. C. E., and is now working satisfactorily. It consists of a double line of "fixed" ropeway, *i. e.*, a down and an up line, upon which the carriers, or hangers, are supported, and are drawn by an endless hauling rope, which is operated by machinery from a turbine that supplies power to the sawmill. The down, or heavy-load line, is a steel-wire rope, 3¾ inches in circumference, whose breaking strain is 42 tons. The up, or light load line, is a steel rope, 3 inches in circumference, with a breaking strain of 25 tons; and the hauling rope is a plow-steel rope, 1¾ inch in circumference, with a breaking strain of from 8 to 9 tons.

Fig. 1 shows a section of the line, which is 8,565 feet in length, and in that distance the ropes are supported at twelve points, the spans unsupported varying in length from 85 feet to 2,230 feet. Figs. 2 and 3 give a side and front elevation of a 23-foot "post," or rope support, with a traveling carrier, or "hanger," to show the mode of transport. At each end of the line suitable stations are erected, details of which are given in plan and elevation (Figs. 4, 5, 6, and 7). The lower, or Santa Maria terminus (Figs. 4 and 5), is erected on a slope close to the sawmill. The upper, or



THE MONTE PENNA WIRE ROPEWAY

Carignone terminus (Figs. 6 and 7), is situated on an exposed mountain ridge, from which a road leads into the forest. The line between is perfectly straight.

The fixed ropes are kept at the required tension by box-weights, suspended at the Carignone terminus to a strong wooden framework, and at the Santa Maria terminus in wells excavated for the purpose. The hauling rope passes round a horizontal drum, with break gear attached at the upper terminus, and round vertical driving and brake-drum gear, guide wheels, and horizontal slide drum, etc., at the lower terminus. The horizontal slide drum regulates the tension of the hauling rope to the required tractive force. The line is driven at a speed of four miles per hour, and can be set in motion or stopped by the person in charge in the station house of the Santa Maria terminus, from which communication is carried on with Carignone by an electric bell telegraph.

Each load is placed on the line 435 meters apart, at which distance rings are spliced into the hauling rope, through which a shackle is passed to connect it to the ear-piece of the carrier head. There are six carriers on the down line and six on the up line, one of which on each line is arranged to arrive at the stations simultaneously. On arrival they are disconnected, and the hauling rope is moved on until the rings are in position to attach on the opposite side. Here another carrier is connected, and the line is again set in motion. The carriers weigh 5 cwt. each, and the loads vary from 6 cwt. to 20 cwt., according to the sizes of timber, etc. All necessaries for the workmen in the forest are sent up on the light-load line in weights up to 1½ cwt.

This ropeway has been constructed in a substantial manner, most of the timber for stations, posts, etc., being injected with a solution of sulphate of copper to retard decay. The total cost of the line was £4,000, including the construction of the short inclined railway at the Santa Maria terminus, telegraph, terminal arrangements, etc. It is capable of conveying eight loads per hour, or per day of ten hours, as many as 200 logs of timber, 10 feet long by 15 inches in diameter; or 320 sacks, = 25 tons, of charcoal, at a working cost of £4 per diem, nearly 50 per cent. of this sum being included for wear and tear of ropes and machinery.—*Engineering.*

Fig. 6.

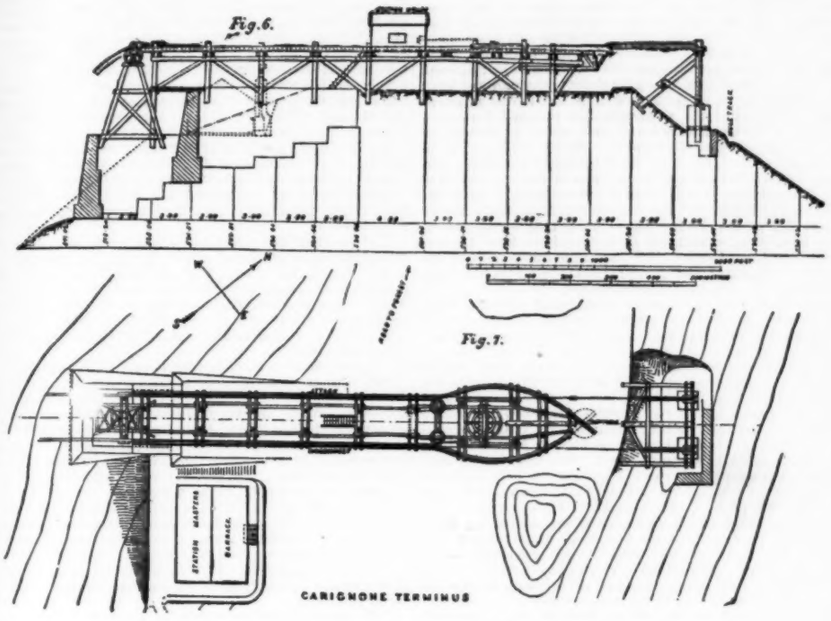


Fig. 7.

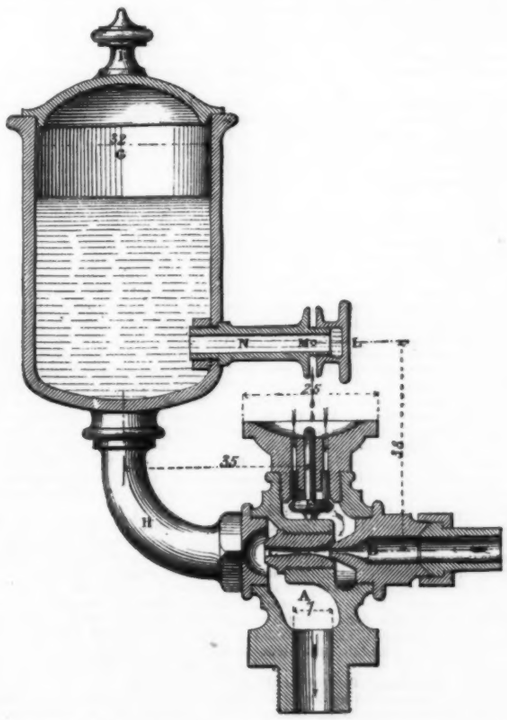
THE MONTE PENNA WIRE ROPEWAY.

ROYLE'S OLEOJECTOR.

THIS apparatus is constructed specially for the lubrication of the cylinders and slide valves of steam engines. It consists of an oil reservoir, G, provided with a tube, N, perforated at M, and having a cap, L, which may be so regulated as to cause the oil to fall drop by drop into the cup, O. From the latter, the lubricant flows out through apertures in the bottom.

At every successive period of low pressure in the cylinder a jet of steam, arriving at B, acts in the manner of an injector and forces the oil into the chamber, A, from whence it flows into the cylinder upon which the apparatus is fixed.

At every period of high pressure in the cylinder the steam, arriving through the chamber, A, beneath the valve, forces the latter to close the apertures of the cup, O, and consequently prevents the oil from entering the cylinder.



ROYLE'S OLEOJECTOR. (Actual Size.)

SEPARATION OF FATS, OILS, GLYCERINE, ETC.

THE following decision of the Supreme Court of the United States, sustaining the Tilghman patent, contains a large amount of valuable information concerning the industries relating to glycerine, fats, and oils. Many interesting allusions to other discoveries are also given:

SUPREME COURT OF THE UNITED STATES.

TILGHMAN *v.* PROCTOR *et al.*

Decided January 24, 1881.

Mr. Justice Bradley delivered the opinion of the Court.

This case involves a consideration of the same patent which was the subject of litigation in the case of *Mitchell* v. *Tilghman*, reported in 19 Wallace, 287. The evidence in the present case, which is quite an unwieldly mass, is much the same as in that, being supplemented, however, by the testimony of the patentee respecting the nature of his original experiments and the practicability of using profitably the coil apparatus described in the patent, together with certain exhibits relating to the novelty of the alleged invention. Upon the renewed consideration which has been given to the subject the Court is unanimously of opinion, contrary to the decision in the Mitchell case, that the patent of Tilghman must be sustained as a patent for a process, and not merely for the particular mode of applying and using the process pointed out in the specification, and that the defendants have infringed it by the processes used by them.

The patent in question relates to the treatment of fats and oils, and is for a process of separating their component parts so as to render them better adapted to the uses of the arts. It was discovered by Chevreul, an eminent French chemist, as early as 1813, that ordinary fat, tallow, and oil are regular chemical compounds, consisting of a base which has been termed "glycerine," and of different acids, termed generally "fat acids," but specifically "stearic," "margaric," and "oleic" acids. These acids, in combination severally with glycerine, form stearine, margarine, and oleine. They are found in different proportions in the various neutral fats and oils, stearine predominating in some, margarine in others, and oleine in others. When separated from their base (glycerine) they take up an equivalent of water and are called "free fat acids." In this state they are in a condition for being utilized in the arts. The stearic and margaric acids form a whitish semi-transparent hard substance, resembling spermaceti, which is manufactured into candles. They are separated from the oleic acid, which is a thin oily fluid, by hydrostatic or other powerful pressure, the oleine being used for manufacturing soap and other purposes. The base (glycerine) when purified has come to be quite a desirable article for many uses.

The complainant's patent is dated the 3d day of October, 1854, and relates back to the 9th day of January of that year, being the date of an English patent granted to the patentee for the same invention. It has but a single claim, the words of which are as follows:

"Having now described the nature of my said invention and the manner of performing the same, I hereby declare that I claim as of my invention—

"The manufacturing of fat acids and glycerine from fatty bodies by the action of water at a high temperature and pressure."

In the case of Mitchell the majority of the Court was of opinion that in the application of the process thus claimed the patentee was confined to the method of using the process particularly pointed out in the specification, and as by that it was proposed to produce a very rapid separation of the fatty elements by the use of a high degree of heat—the operation being effected in the space of ten minutes by forcing the fat mixed with water through a long coil of strong iron tube passing through an oven or furnace, where it was subjected to a temperature equal to that of melting lead, or 612° Fahrenheit—it was concluded by the Court that the producing of the same result in a boiler subjected to only 400° Fahrenheit, and requiring a period of several hours to effect the desired separation, was not an infringement of the patent, although the process by which the effect was produced—namely, the action of water in intimate mixture with the fat at a high temperature and under a sufficient pressure to prevent the formation of steam—was undoubtedly the same. On further reflection we are of opinion that in the case referred to sufficient consideration was not given to the fact that the patent is for a process, and not for any specific mechanism for carrying such process into effect.

In order to have a clearer understanding of the question it is necessary to advert briefly to the history of the art, and then to examine the terms of the patent in greater detail.

It is conceded by the complainant that two different processes for effecting a decomposition of fats into their component elements had been in practical operation prior to his invention. These processes were called, respectively, the "alkaline-saponification process" and the "sulphuric-acid-distillation process." The first consisted of the manufacture of the fat into soap by the use of lime or other alkali, and then of the decomposition of the soap so produced into the fat acids by the aid of hydrochloric or dilute sulphuric acid. The decomposition of the soap was, by a subsequent improvement, effected by distillation in an atmosphere of steam. The other process, called the "sulphuric-acid distillation process," consisted of the direct saponification of fat by means of concentrated sulphuric acid, and the subsequent distillation over of the resulting fatty acids. By this process, however, the glycerine was destroyed.

DECOMPOSITION OF FATS—HISTORY OF.

The first of these processes was patented by Gay Lussac & Chevreul in 1825, but was not brought into successful operation in the manufacture of stearic candles until improved by De Milly in 1831. The second process was proposed and developed between 1840 and 1850. It was extensively used during and after that period by the large manufacturing firm of E. Price & Co., of London, and their successors, Price's Patent Candle Company. Mr. G. F. Wilson, one of the shareholders in that establishment, and apparently a man of accurate knowledge on this subject, read various papers illustrative of the history of the manufacture before learned societies in England, extracts from which are contained in the record and throw considerable light on the matter. It appears from his statements that the distillation of the saponified fat, whether saponified by an alkali or by sulphuric acid, was often accompanied by prejudicial effects from the access of atmospheric air to the contents of the still. To remedy this he and his associates adopted and patented the introduction of superheated steam into the still or vat containing the fat acids, which

excluded atmospheric air, and carried over the fatty vapors into the receiver in a more perfect condition than they had before been able to obtain them. These patents were taken out in 1843. In the following year the same parties, Gwynne and Wilson, found, what Dubrunfaut had found two or three years before, that palm-oil, which is very fusible and manageable, can be distilled in its crude state in the manner last described—that is, by the introduction of steam into the still without the intervention of saponification—and the distilled product being then steam-boiled in water acidulated with sulphuric acid, and the water allowed to settle and separate, the resulting substance would be a fat acid. It is not shown that this process was ever carried into successful operation prior to Tilghman's patent; and, judging from what was done by the Price Patent Candle Company in the way of improvement immediately after becoming acquainted with Tilghman's process, it is to be inferred that the steam-distillation process (without saponification) was still an unsuccessful experiment when his patent was issued. This experiment, however, must be regarded as the nearest approach to the process of Tilghman of anything done in the art prior to it.

We do not regard the accidental formation of fat acid in Perkins's steam cylinder from the tallow introduced to lubricate the piston (if the scum which rose on the water issuing from the ejection pipe was fat acid) as of any consequence in this inquiry. What the process was by which it was generated or formed was never fully understood. Those engaged in the art of making candles, or in any other art in which fat acids are desirable, certainly never derived the least hint from this accidental phenomenon in regard to any practicable process for manufacturing such acids.

The accidental effects produced in Daniell's water-barometer and in Walther's process for purifying fats and oils preparatory to soap-making are of the same character. They revealed no process for the manufacture of fat acids. If the acids were accidentally and unwittingly produced while the operators were in pursuit of other and different results, without exciting attention, and without its even being known what was done or how it had been done, it would be absurd to say that this was an anticipation of Tilghman's discovery.

Nor do we regard the patent of Manicler, which was taken out in 1826, as anticipating the process of Tilghman. It is true that he directs a mixture of fat with about one quarter of its weight of water to be placed in a boiler and subjected to a heat sufficient to create a pressure equal to one atmosphere above the natural atmospheric pressure, or about 250° Fahrenheit, the boiler being provided with a safety-valve which would secure that degree of pressure. But, subject to this pressure, the patent directed that the mixture should be made to boil, and, of course, that the water should be converted into steam. The words are "apply fire to this digester to melt and digest the contained tallow or fat and water, and keep up a rapid ebullition during about six hours." It is probable, therefore, that any decomposition of the fat which may have been produced by this process was due to the steam formed and passing through the fat, as no means appears to have been adopted for keeping up the mixture of the fat and water. But we have no evidence that the process was ever successful in practice. One of the defendant's witnesses testifies that he tried it, and though he got some results, he adds this pregnant observation:

"To transform all the fat in this way at so low a temperature would have required many days."

He only pretends that the sample which he obtained showed by its appearance, as well as by its acid action, that the separation had commenced. Evidently, therefore, this was but an abandoned experiment, since we never hear any more of it from 1826 down to the trial of this cause.

It is unnecessary to examine in detail other alleged anticipations of Tilghman's process. We believe that we have specified the most prominent and reliable instances.

Tilghman's discovery was made in 1853, and was, in brief, this: That the fat acids can be separated from glycerine, without injury to the latter, by the single and simple process of subjecting the neutral fat while in intimate mixture with water to a high degree of heat, under sufficient pressure to prevent the water from being converted into steam, without the employment of any alkali or sulphuric acid or other saponifying agent, the operation, even with the most solid fats being capable of completion in a very few minutes when the heat applied is equal to that of melting lead, or 612° Fahrenheit, but requiring several hours when it is as low as 350° or 400° Fahrenheit. The only conditions are a constant and intimate commixture of the fat with the water, a high degree of heat, and a pressure sufficiently powerful to resist the conversion of the water into steam. The result is a decomposition of the fatty body into its elements of glycerine and fat acids, each element taking up the requisite equivalent of water essential to its separate existence, and the glycerine in solution separating itself from the fat acids by settling to the bottom, when the mixed products are allowed to stand and cool. In this process a chemical change takes place in the fat in consequence of the presence of the water and the active influence of the heat and pressure upon the mixture.

We are satisfied that Tilghman was the original discoverer of this process. His priority was acknowledged at the time by those most interested to question it. Mr. Wilson, to whose statements reference has been made, and who is, perhaps, more justly entitled than any one else to claim an anticipation of Tilghman's discovery, makes no such pretension, but, on the contrary, concedes Tilghman's right to priority; and, indeed, Price's Patent Candle Company, of which Mr. Wilson was a member and director, took a license under Tilghman's English patent.

As having some bearing upon the proper construction of the patent in suit (which will presently be more particularly examined), it is proper to observe that Tilghman's actual invention, as demonstrated in his experiments made in 1853, before making any application for a patent, was not confined to the use of a coil of pipe in a heated chamber or furnace for effecting the process which he claims, but was frequently exhibited by using a simple digester filled nearly full with a mixture of fat and water and heated in a gas-stove or in a vertical position over a gas-lamp, the mixture of fat with the water being kept up by a loose metallic rod or jumper, which thoroughly mixed the contents when the digester was shaken. Sometimes the digester was heated in a horizontal position, and, being provided with thin copper partitions fixed inside, was made to revolve in order to cause a more perfect mixture of the materials. In using the digester, it not being provided with a safety valve, a small space was left at the top for the formation of sufficient steam to prevent, by its elasticity, the vessel from exploding. In making these experiments Tilghman not only varied the apparatus, but applied different degrees of heat in the operation.

The following is his account of some of these proceedings. He says:

"Before applying for my patent I had made many experiments in decomposing by water at temperatures below melting bismuth, sometimes in the coil form of apparatus, but most frequently in digesters. The lowest temperature tried by me was three hundred and fifty degrees (350°) Fahrenheit or one hundred and twenty pounds pressure continued for four hours. The digester was, as usual, in a vertical position, but the heat was in this case given by an oil bath. I obtained both fat acids and glycerine in this experiment, but in such small quantities as to prove that though the decomposition did go on at that heat, yet it was very slow compared with the higher heats. I find notes of another experiment (July 15, 1854) in the coil apparatus with palm oil, made at the melting point of tin, 440° Fahrenheit, three hundred and sixty pounds pressure. It was pumped through the coil very slowly, so as to give about thirty minutes' heat, and found to be partly decomposed, so that it was returned to the inlet end of the apparatus and pumped through a second time at the same rate and heat, which produced perfect decomposition of the palm oil into fat acids and solution of glycerine. Ten minutes' exposure would have perfectly decomposed palm oil at the heat of melting bismuth, (510° Fahrenheit). Yet I found 70° lower heat required six times as long to produce the same effect. I had often decomposed tallow at 510° Fahrenheit before taking out my patent, not in the coil apparatus, but in the simple vertical digester. In this case I had to allow increased time on account of the imperfect contact of the fat and water in addition to that required by the diminished temperature."

In the course of his testimony, Tilghman explains why, in his patent, he specially recommended the use of the high temperature of melting lead in applying his process to practical use. He says:

"Many experiments had shown me that at these higher temperatures the decomposition was carried on with the greatest economy of fuel and cost of apparatus. When in London in 1847 I had found Perkins's house-warming apparatus, consisting of coils of hundreds of feet of pipe containing water at the temperature of melting lead, had long been in extensive domestic use there. On returning to London in 1853 I found the same apparatus largely used for heating bakers' ovens. As I thus found such heats and pressures were perfectly practical and safe, as well as economical, I thought I was bound to describe my invention in what I then believed to be the best mode of carrying it out, and that, as I was the discoverer of the chemical fats, I could then claim, broadly, as my process the use of water highly heated and under pressure to decompose fats, no matter what temperature or apparatus was used."

And being asked for his present views as to the practicability, economy, and safety of the higher temperatures as compared with lower temperatures, he said:

"I think the high pressure apparatus is much more economical, both in the first cost and the expense of working. Its principal disadvantage is that ordinary engineers are not familiar with its management, and consequently dislike it."

In December, 1853, Tilghman having completed his experiments to his own satisfaction, filed a caveat in the Patent Office preparatory to taking out a patent for his invention. In this caveat he says:

"The invention consists in subjecting animal and vegetable fatty and oily substances containing glycerine to a high temperature and pressure in close vessels, mixed with different agents, according to the effect desired to be produced upon the fatty matter. Thus, when I wish to convert the neutral fatty substances into fatty acids and glycerine, I pump a mixture of the fat and water, under great pressure, through a series of strong metal tubes kept at about the heat of melting lead and provided with a cooling-worm and safety valve at its outlet. The neutral fatty substance is decomposed by the process, and the fat acid and solution of glycerine which issues through the safety valve separate by settling."

Tilghman soon after repaired to England and took out a patent there, dated the 9th day of January, 1854, and sealed the 25th of March. He immediately put in operation an apparatus for exhibiting his process on a small scale. Mr. Wilson, before mentioned, witnessed his experiments, and thus speaks of them in a paper communicated to the *Journal of the Society of Arts*, January 25, 1856:

"In January, 1854, Mr. Tilghman, an American chemist, who has studied all that has been published here and in France on the subject of acidification and distillation of fatty bodies, obtained a patent for exposing fats and oils to the action of fat at a high temperature and under great pressure, in order to cause the combination of the water with the elements of the neutral fats, so as to produce at the same time free fat acids and solution of glycerine. He proposed to effect this by pumping a mixture of fat and water by means of a force pump through a coil of pipe heated to about 612° Fahrenheit, kept under a pressure of about two thousand pounds to the square inch, and he states that the vessel must be closed so that the requisite amount of pressure may be applied to prevent the conversion of water into steam. This is, all must admit, a beautiful, original, chemical idea, well carried out. It has yet to prove how far it can compete successfully with distillation. We have made an arrangement with Mr. Tilghman which will give us the means of testing its commercial merits."

Mr. Wilson goes on to state that this process of Tilghman suggested to them the idea of distilling fats by passing steam into them at a high temperature, whereby to resolve them into glycerine and fat acids. They found the plan successful, and that the glycerine distilled over with the fat acids, but no longer combined with them, and in July, 1854, they took out a patent for that purpose. In a paper read before the Glasgow meeting of the British Association for the Advancement of Science, in September, 1855, Mr. Wilson thus refers to the course of discovery which took place in this branch of manufacture:

"By our first improvement in separating the fat acids from neutral fats the glycerine was decomposed by the direct action of concentrated sulphuric acid at a high temperature, and all that remained of it was a charred precipitate. A new process for decomposing neutral fats by water under great pressure, coming under our notice, referring to Tilghman's process, led us to look again more closely into our old distilling processes, and the doing this showed, what we had often been on the brink of discovering, that glycerine might be distilled.

"In our new process the only chemical agents employed for decomposing the neutral fat and separating its glycerine are steam and heat, and the only agents used in purifying the glycerine thus obtained are heat and steam. Thus all trouble from earthy salts or lead is escaped. Distillation, however, purifies the impure glycerine of the old sources.

"On the table is a series of products of palm oil, which will serve to illustrate the process. Steam at a temperature of from 550° to 600° Fahrenheit is introduced into a distillery apparatus containing a quantity of palm oil. The fatty acids take up their equivalents of water and the glycerine takes up its equivalent. They then distill over together. In the receiver the condensed glycerine, from its higher specific gravity, sinks below the fat acids."

We quote more fully from this paper because it is a contemporary acknowledgment, made by a man who stood in the front rank of those who understood and whose interest it was to understand the most advanced process of resolving fats and oils into their component parts, that Tilghman's "process for decomposing neutral fats by water under great pressure" was "a new process," and who, with his associates, took hints from it for making new departures and improvements in the art. The statements of Mr. Wilson on this subject are corroborated by other witnesses. Indeed, nearly all those competent to speak on the subject state or admit that the process of decomposing fats into glycerine and fat acids by mixing them with water and subjecting the mixture to a high degree of heat under a pressure sufficient to prevent the conversion of the water into steam was not known in the arts prior to Tilghman's discovery. The testimony of some experts to the contrary is based upon their construction of certain patents and publications produced in evidence, the most important of which have already been adverted to.

The question then arises, has Tilghman secured the exclusive right to the process of which he was thus the inventor?

An examination of the patent itself, which the preceding remarks will enable us better to understand, will show, we think, that it was intended to and does cover and secure to the patentee the general process which has been described, although only one particular method of applying and using it is pointed out.

The specification describes the invention as follows:

"My invention consists of a process for producing free fat acids and solution of glycerine from those fatty and oily bodies of animal and vegetable origin which contain glycerine as their base. For this purpose I subject these fatty or oily bodies to the action of water at a high temperature and pressure, so as to cause the elements of those bodies to combine with water, and thereby obtain at the same time free fat acids and solution of glycerine. I mix the fatty body to be operated upon with from a third to half of its bulk of water, and the mixture may be placed in any convenient vessel in which it can be heated to the melting point of lead until the operation is complete. The vessel must be closed and of great strength, so that the requisite amount of pressure may be applied to prevent the conversion of the water into steam.

"The process may be performed more rapidly and also continuously by causing the mixture of fatty matter and water to pass through a tube or continuous channel heated to the temperature already mentioned, the requisite pressure for preventing the conversion of water into steam being applied during the process, and this I believe is the best mode of carrying my invention into effect. In the drawings hereunto annexed are shown figures of an apparatus for performing this process speedily and continuously, but which apparatus I do not intend to claim as any part of my invention."

The specification then goes on to describe, by the aid of the drawing referred to, the particular device mentioned; but it is evident, and indeed is expressly announced, that the process claimed does not have reference to this particular device, for the apparatus described was well known, being similar to that used for producing the hot-blast and for heating water for the purpose of warming houses. It consists of a coil of iron pipe or other metallic tubing erected in an oven or furnace, where it can be subjected to a high degree of heat, and through this pipe the mixture (of nearly equal parts of fat and water), made into an emulsion in a separate vessel by means of a rapidly vibrating piston or dasher, is impelled by a force-pump in a nearly continuous current with such regulated velocity as to subject it to the heat of the furnace for a proper length of time to produce the desired result, which time, when the furnace is heated to the temperature of 612° Fahrenheit, is only about ten minutes. The fat and water are kept from separating by the vertical position of the tubes, as well as by the constant movement of the current, and are prevented from being converted into steam by weighting the exit-valve by which the product is discharged into the receiving vessel, so that none of it can escape except as it is expelled by the pulsations produced by the working of the force pump. Before arriving at the exit valve the pipe is passed in a second coil through an exterior vessel filled with water, by which the temperature of the product is reduced. After the product is discharged into the receiving vessel it is allowed to stand and cool until the glycerine settles to the bottom and separates itself from the fat acids. The latter are then subjected to washing and hydraulic pressure in the usual way. After describing this apparatus, it is added:

"Although the decomposition of the neutral fats by water takes place with great quickness at the proper heat, yet I prefer that the pump should be worked at such a rate, in proportion to the length or capacity of the heating tubes, that the mixture, while flowing through them, should be maintained at the desired temperature for ten minutes before it passes into the refrigerator or cooling part of the apparatus."

It is evident that the passing of the mixture of fat and water through a heated coil of pipe standing in a furnace is only one of several ways in which the process may be applied. The patentee suggests it as what he conceived to be the best way, apparently because the result is produced with great rapidity and completeness. But other forms of apparatus, known and in public use at the time, can as well be employed without changing the process. A common digester or boiler can evidently be so used, provided proper means are employed to keep up the constant admixture of the water and fat, which is a *sine qua non* in the operation. Tilghman himself, as we have seen, often used such digesters in making his experiments before applying for his patent; and in putting up machinery for his licensees after his patent was obtained he did the same thing when the parties desired it. Yet surely the identity of the process was not changed by thus changing the form of apparatus. No great amount of invention was required to adapt different forms of well-known apparatus to the application of the process. The principal difficulty would be in providing an internal arrangement in the boiler or digester for successfully keeping up the intimate commixture of the fat and water. It is evident that this could be accomplished by means of revolving reels armed with buckets, or of a force pump constantly transferring the heavy stratum of water from the bottom of the mass to the top, aided by horizontal diaphragms partially sectionizing the digester. These de-

vices were resorted to by Tilghman and others when they used a boiler instead of a coil of pipe.

While Tilghman in his patent recommends the high degree of heat named, he does not confine himself to that. It had been fully developed in his experiments, and was well known to him, that a lower degree of heat could be employed by taking longer time to perform the operation, and this would be necessary when boilers or digesters of considerable size were used instead of the coil of pipe on account of the decreasing power of large vessels to resist the internal pressure. The specification, after describing the use of a metallic coil of pipe, proceeds to add:

"The melting point of lead has been mentioned as the proper heat to be used in this operation, because it has been found to give good results. But the change of fatty matters into fat acid and glycerine takes place with some materials (such as palm oil) at or below the melting point of bismuth, 510° Fahrenheit; yet the heat has been carried considerably above the melting point of lead without any apparent injury, and the decomposing action of the water becomes more powerful as the heat is increased. By starting the apparatus at a low heat and gradually increasing it the temperature-giving products most suitable to the intended application of the fatty body employed can easily be determined."

Now, when we find it stated, as we do in this specification, that the patentee subjects "fatty or oily bodies to the action of water at a high temperature and pressure, so as to cause the elements of those bodies to combine with water;" that "the mixture may be placed in any convenient vessel in which it can be heated to the melting point of lead until the operation is complete;" that "the vessel must be closed and of great strength, so that the requisite amount of pressure may be applied to prevent the conversion of the water into steam;" that "the decomposition of the neutral fats by water takes place with great quickness at the proper heat;" that "the melting point of lead has been mentioned as the proper heat to be used in this operation, because it has been found to give good results;" that "the change of fatty matters into fat acid and glycerine takes place with some materials at or below the melting point of bismuth;" that "the decomposing action of water becomes more powerful as the heat is increased;" that "by starting the apparatus at a low heat and gradually increasing it the temperature-giving products most suitable to the intended application of the fatty body employed can easily be determined;" and when we then find that the patentee categorically claims, in general terms, as his invention "the manufacturing of fat acids and glycerine from fatty bodies by the action of water at a high temperature and pressure," and being satisfied that he was, in fact, the inventor of the general process described and bodied forth in the specification, how can we, by any fair rule of construction, circumscribe this claim in such a manner as that it shall only cover the process when applied in the use of a coil of pipe heated to 612° Fahrenheit? Or, if we allow it to embrace any "convenient vessel," and do not confine it to a coil of pipe, how can we confine it to a particular degree of heat? What did Tilghman discover, and what did he, in terms, claim by his patent? He discovered that fat can be dissolved into its constituent elements by the use of water alone under a high degree of heat and pressure, and he patented the process of "manufacturing fat acids and glycerine from fatty bodies by the action of water at a high temperature and pressure." Had the process been known and used before, and not been Tilghman's invention, he could not then have claimed anything more than the particular apparatus described in his patent; but being the inventor of the process, as we are satisfied was the fact, he was entitled to claim it in the manner he did.

PATENTS FOR PROCESSES.

That a patent can be granted for a process there can be no doubt. The patent law is not confined to new machines and new compositions of matter, but extends to any new and useful art of manufacture. A manufacturing process is clearly an art within the meaning of the law. Goodyear's patent was for a process, namely, the process of vulcanizing India-rubber by subjecting it to a high degree of heat when mixed with sulphur and a mineral salt. The apparatus for performing the process was not patented, and was not material. The patent pointed out how the process could be effected, and that was deemed sufficient. Neilson's patent was for the process of applying the hot blast to furnaces by forcing the blast through a vessel or receptacle situated between the blowing apparatus and the furnace, and heated to a red heat, the form of the heated vessel being stated by the patent to be immaterial. These patents were sustained after the strictest scrutiny and against the strongest opposition.

On the subject of patents for processes, Mr. Justice Grier, in delivering the opinion of this Court in *Corning v. Burden* (15 How., 267), said:

"A process *eo nomine* is not made the subject of a patent in our act of Congress. It is included under the general term 'useful art.' An art may require one or more processes in order to produce a certain result or manufacture. The term 'machine' includes every mechanical device or combination of mechanical powers and devices to perform some function or to produce a certain effect or result. But where the result or effect is produced by chemical action, by the operation or application of some element or power of nature, or of one substance to another, such modes, methods, or operations are called 'processes.' A new process is usually the result of a discovery—a machine or invention. The arts of tanning, dyeing, making waterproof cloth, vulcanizing India-rubber, smelting ores, and numerous others are usually carried on by processes as distinguished from machines. One may discover a new and useful improvement in the process of tanning, dyeing, etc., irrespective of any particular form of machinery or mechanical device, and another may invent a labor-saving machine, by which the operation or process may be performed, and each may be entitled to his patent. As, for instance: A has discovered that by exposing India-rubber to a certain degree of heat in mixture or in connection with certain metallic salts he can produce a valuable product or manufacture. He is entitled to a patent for his discovery as a process or improvement in the art irrespective of any machine or mechanical device. B, on the contrary, may invent a new furnace or stove or steam apparatus, by which this process may be carried on with much saving of labor and expense of fuel, and he will be entitled to a patent for his machine as an improvement in the art."

NEILSON'S HOT BLAST PROCESS.

Neilson's patent, above referred to, had some features very similar to those of Tilghman's. The strong objection urged against the latter is that the particular apparatus described in the specification is not that which is generally used, and that it cannot be used with much profit or success in large manufacturing operations, whereas the slower method of dissolving fats in a common boiler or digester at a lower temperature even than that of melting bismuth, which is not described in the specification, is the one which is generally adopted. Precisely this circumstance existed in reference to the patent of Neilson. The specification directed that the blast or current of air produced by the blowing apparatus should be passed into an air vessel or receptacle heated to a red heat, and from thence into the furnace. Then, after stating that the air vessel or receptacle should be increased in size according to the size of the forge or furnace to be supplied, the specification adds:

"The form or shape of the vessel or receptacle is immaterial to the effect and may be adapted to the local circumstances or situation."

Now, the most simple and natural form of an air-vessel for heating the blast, as here directed, would be a box or chamber or a cylindrical vessel; but it turned out in practice that a receptacle of this kind would answer the purpose but very imperfectly, and that the best and most useful method was to heat the blast in a series of tubes placed in a heated oven. This was held to be no ground for invalidating the patent or for preventing it from covering intermediate tubes, as well as an intermediate box or chamber, the jury being of opinion that a man of ordinary skill and knowledge in the construction of blowing and air-heating apparatus would be able, from the information contained in the specification, to erect a machine which would answer some beneficial purpose in the application of the process, and would not be misled and prevented from so doing by the declaration that the form or shape of the vessel or receptacle was immaterial to the effect. In this view of the subject the patent was sustained after very great consideration.

Some question has indeed been made whether Neilson's patent was sustained as a patent for a process. The Court of Exchequer, in reviewing the proceedings at a trial, and answering the objection that it was a patent for a principle, said:

"It is very difficult to distinguish it from the specification of a patent for a principle, and this at first created in the minds of some of the court much difficulty; but after full consideration we think that the plaintiff does not merely claim a principle, but a machine embodying a principle, and a very valuable one. We think the case must be considered as if, the principle being well known, the plaintiff had first invented a mode of applying it by a mechanical apparatus to furnaces, and his invention consists in this, by interposing a receptacle for heated air between the blowing apparatus and the furnace. In this receptacle he directs the air to be heated by the application of heat externally to the receptacle, and thus he accomplishes the object of applying the blast, which was before of cold air, in a heated state to the furnace. (Webster's Rep., 371.)"

In this passage we think that the Court of Exchequer (who spoke through Baron Parke) drew the true distinction between a mere principle as the subject of a patent and a process by which a principle is applied to effect a useful result. That a hot blast is better than a cold blast for smelting iron in a furnace was the principle or scientific fact discovered by Neilson. And yet, being nothing but a principle, he could not have a patent for that. But, having invented and practically exemplified a process for utilizing this principle—namely, that of heating the blast in a receptacle between the blowing apparatus and the furnace—he was entitled to a patent for that process, although he did not distinctly point out all the forms of apparatus by which the process might be applied, having nevertheless pointed out a particular apparatus for that purpose, and having thus shown that the process could be practically and usefully applied. Another person might invent a better apparatus for applying the process than that pointed out by Neilson, and might obtain a patent for such improved apparatus, but he could not use the process without a license from Neilson. His improved apparatus would in this respect stand in a relation to the process analogous to that which an improvement on a patented machine bears to the machine itself.

That Neilson's patent was regarded as for a process is apparent from what is said by the judges who had it under consideration. Thus Baron Parke at the trial had said:

"The specification and patent together make it clear what the discovery was. It was the introduction of hot air by means of heating it before it was introduced into the furnace between the blowing apparatus and the furnace. (Webster, 312.)"

And when the matter came before the House of Lords, after a trial in Scotland, Lord Campbell said:

"After the construction first put upon it (the patent) by the learned judges of the Court of Exchequer, sanctioned by the high authority of my noble and learned friend now upon the woolsack, when presiding in the Court of Chancery, I think the patent must be taken to extend to all machines, of whatever construction; whereby the air is heated immediately between the blowing apparatus and the blast furnace. That being so, the learned judge was perfectly justified in telling the jury that it was unnecessary for them to compare one apparatus with another, because, confessedly, that system of conduit pipes was a mode of heating air by an intermediate vessel between the blowing apparatus and the blast furnace, and therefore it was an infraction of the patent. (Webster, 715.)"

This case of the hot blast was commented upon in the great case of *O'Reilly v. Morse*, reported in 15 Howard, 62, and is there recognized and approved in the opinion of the Court, delivered by Chief Justice Taney. After quoting the remarks of Baron Parke in the Court of Exchequer, cited above, the Chief Justice says:

"We see nothing in this opinion differing in any degree from the familiar principles of law applicable to patent cases. Neilson claimed no particular mode of constructing the receptacle or of heating it. He pointed out the manner in which it might be done, but admitted that it might also be done in a variety of ways, and at a higher or lower temperature, and that all of them would produce the effect in a greater or less degree, provided the air was heated by passing through a heated receptacle. . . . Whoever, therefore, used this method of throwing hot air into the furnace used the process he had invented, and thereby infringed his patent, although the form of the receptacle or the mechanical arrangements for heating it might be different from those described by the patentee, for whatever form was adopted for the receptacle, or whatever mechanical arrangements were made for heating it, the effect would be produced in a greater or less degree if the heated receptacle was placed between the blower and the furnace, and the current of air passed through it. . . . The patent was supported because he (Neilson) had invented a mechanical apparatus, by which a current of hot air, instead of cold, could be thrown in, and this new method was protected by the patent. The interposition of a heated receptacle in any form was the novelty he invented. (15 How., 115, 116.)"

MORSE'S TELEGRAPH PATENT.

We have quoted these remarks of the Chief Justice more fully because they show most clearly that he put the same construction upon Neilson's patent that was put upon it by Lord Campbell, and that he fully acquiesced in the legality and validity of a patent for a process. Yet it has been supposed that the decision in *O'Reilly v. Morse* was adverse to patents for mere processes. The mistake has undoubtedly arisen from confounding a patent for a process with a patent for a mere principle. We think that a careful examination of the judgment in that case will show that nothing adverse to patents for processes is contained in it. The eighth claim of Morse's patent was held to be invalid because it was regarded by the Court as being not for a process, but for a mere principle. It amounted to this, namely, a claim of the exclusive right to the use of electro-magnetism as a motive power for making intelligible marks at a distance—that is, a claim to the exclusive use of one of the powers of nature for a particular purpose. It was not a claim of any particular machinery, nor a claim of any particular process for utilizing the power, but a claim of the power itself—a claim put forward on the ground that the patentee was the first to discover that it could thus be employed. This claim the Court held could not be sustained. That this was the true ground of the decision will be manifest from the following observations of the Chief Justice in the opinion already quoted from. He says:

"He (Morse) claims the exclusive right to every improvement where the motive power is the electric or galvanic current, and the result is the marking or printing intelligible characters, signs, or letters at a distance. If this claim can be maintained, it matters not by what process or machinery the result is accomplished. For aught that we now know some future inventor, in the onward march of science, may discover a mode of writing or printing at a distance by means of the electric or galvanic current without using any part of the process or combination set forth in the plaintiff's specification. . . . In fine, he claims an exclusive right to use a manner and process which he has not described, and indeed had not invented, and therefore could not describe, when he obtained his patent. The Court is of opinion that the claim is too broad and not warranted by law. . . . It is the high praise of Professor Morse that he has been able by a new combination of known powers, of which electro-magnetism is one, to discover a method by which intelligible marks or signs may be printed at a distance; and for the method or process thus discovered he is entitled to a patent. But he has not discovered that the electro-magnetic current used as a motive power in any other method and with any other combinations will do as well."

WHO MAY OBTAIN PATENTS.

After reviewing the statutes and decisions bearing upon the subject the Chief Justice makes a summary conclusion of the whole matter as follows:

"Whoever discovers that a certain useful result will be produced in any art, machine, manufacture, or composition of matter by the use of certain means is entitled to a patent for it, provided he specifies the means he uses in a manner so full and exact that any one skilled in the science to which it appertains, can, by using the means he specifies, without any addition to or subtraction from them, produce precisely the result he describes. And if this cannot be done by the means he describes the patent is void. And if it can be done, then the patent confers on him the exclusive right to use the means he specifies to produce the result or effect he describes, and nothing more. And it makes no difference in this respect whether the effect is produced by chemical agency or combination, or by the application of discoveries or principles in natural philosophy known or unknown before his invention, or by machinery acting altogether upon mechanical principles. In either case he must describe the manner or process as above mentioned and the end it accomplishes. And any one may lawfully accomplish the same end without infringing the patent if he uses means substantially different from those described. (15 How., 119)."

It seems to us that this clear and exact summary of the law affords the key to almost every case that can arise. "Whoever discovers that a certain useful result will be produced in any art by the use of certain means is entitled to a patent for it, provided he specifies the means." But everything turns on the force and meaning of the word "means." It is very certain that the means need not be a machine or an apparatus. It may, as the Court says, be a process. A machine is a thing. A process is an act or a mode of acting. The one is visible to the eye—an object of perpetual observation. The other is a conception of the mind, seen only by its effects when being executed or performed. Either may be the means of producing a useful result. The mixing of certain substances together or the heating of a substance to a certain temperature is a process. If the mode of doing it or the apparatus in or by which it may be done is sufficiently obvious to suggest itself to a person skilled in the particular art, it is enough in the patent to point out the process to be performed without giving supererogatory directions as to the apparatus or method to be employed. If the mode of applying the process is not obvious, then a description of a particular mode by which it may be applied is sufficient. There is, then, a description of the process and of one practical mode in which it may be applied. Perhaps the process is susceptible of being applied in many modes and by the use of many forms of apparatus. The inventor is not bound to describe them all in order to secure to himself the exclusive right to the process if he is really its inventor or discoverer. But he must describe some particular mode or some apparatus by which the process can be applied with at least some beneficial result, in order to show that it is capable of being exhibited and performed in actual experience.

Let us apply these principles to the present case. In the first place, the claim of the patent is not for a mere principle. The chemical principle or scientific fact upon which it is founded is that the elements of neutral fat require to be severally united with an atomic equivalent of water in order to separate from each other and become free. This chemical fact was not discovered by Tilghman. He only claims to have invented a particular mode of bringing about the desired chemical union between the fatty elements and water. He does not claim every mode of accomplishing this result. He does not claim the lime saponification process, nor the sulphuric acid distillation process, and if, as contended, the result was accomplished by Dubrunfaut, Wilson, and Scharling, by means of steam distillation, he does not claim that process. He only claims the process of subjecting to a high degree of heat a mixture continually kept up of nearly equal quantities of fat and water in a convenient

vessel strong enough to resist the effort of the mixture to convert itself into steam. This is most certainly a process. It is clearly pointed out in the specification, and one particular mode of applying it and carrying it into effect is described in detail. But it is not the particular apparatus described which Tilghman desires to secure by his patent. Having pointed out the process and suggested a particular mode of applying it, he claims as his invention "the manufacturing of fat acids and glycerine from fatty bodies by the action of water at a high temperature and pressure." The true construction of this claim is to be sought by comparing it, as we have already done, with the context of the specification; with the statement of the patentee that his "invention consists of a process for producing free fat acids and solution of glycerine from those fatty and oily bodies of animal and vegetable origin which contain glycerine as a base;" that "for this purpose he subjects these fatty and oily bodies to the action of water at a high temperature and pressure, so as to cause the elements of those bodies to combine with water, and thereby obtain at the same time free fat acids and solution of glycerine;" that he "mixes the fatty body to be operated upon with from a third to a half of its bulk of water, and the mixture may be placed in any convenient vessel in which it can be heated to the melting point of lead" (which is afterward explained to be only desirable for a quick result, not essential); that "the vessel must be closed and of great strength, so that the requisite amount of pressure may be applied to prevent the conversion of the water into steam." This is the process which the patentee claims to have invented, and this description of it gives the proper construction and qualification to the claim.

It is objected that the particular apparatus described in the patent for carrying the process into effect can not be operated to produce any useful result. We have examined the evidence on this point and are satisfied that it shows the objection to be unfounded. A recapitulation of this evidence is not necessary. The testimony of Tilghman himself, of Professor Booth, and of Mr. Wilson is directly to the point.

THE QUESTION OF INFRINGEMENT.

It only remains that we should express our views on the question of infringement. The defendants advance several reasons for the purpose of showing that their process does not conflict with that of Tilghman: First, because they do not use the apparatus described in the complainant's patent, but use a boiler in which the charge of fat and other materials is placed and heated, and do not mix the fat and water in the manner pointed out in the specification of the patent, but, on the contrary, have inserted in the boiler a pump which forces the water as it settles to the bottom upward to the top of the mass and pours it upon the upper surface, whence it again finds its way down through the fat, thus keeping up a constant mixture. It is unnecessary to add anything further on the subject of the form of the apparatus used. The patentee is not confined to a metallic coil of pipe heated in a furnace, but his patent extends to and embraces any convenient vessel for holding the mixture which is strong enough to sustain the pressure necessary to prevent the water from being converted into steam. The defendants use such a vessel, and use it for the purpose indicated and pointed out in the patent. The vessel which they use has the requisite strength to prevent the water from being converted into steam, and does effect that object. And as to the defendants using a different method from that suggested in the patent for keeping up the mixture of fat and water, that is of no consequence. The keeping up of the mixture is the important thing. That is a necessary part of the process. They employ such a device for effecting this as is adapted to the form of vessel in which they heat the material. Using a boiler instead of a coil of pipe for this purpose, they are obliged to employ an additional or modified means for keeping up the mixture. They only employ such means as, in view of the change adopted in the form of the heating apparatus and of the known appliances in use in analogous processes, would naturally suggest themselves to a mechanic skilled in the art. Or, if the mode of effecting the continued mixture adopted by the defendants should be deemed a new and useful improvement, they might, perhaps, have a patent for that peculiar device without being entitled to use Tilghman's process, on which it is but an improvement.

Another ground on which the defendants argue that they do not infringe the patent is that they do not in their process use water alone in admixture with fat, but use also some portion of lime; that they formerly used seven per cent. of lime and now use four per cent. But they do not use lime in the manner and to the extent in which it is used for dissolving fats by the saponifying process. That requires twelve or fourteen per cent. Even if the saponifying process partly takes place, they use Tilghman's process for effecting the balance of the operation. They use water in admixture with fat heated to a high degree far above the boiling point, and yet subjected to such pressure as to prevent the water from being converted into steam, and though they may also use other things at the same time, which other things may facilitate the operation or render a less degree of heat necessary than would be required when water alone is used, and thus actually improve the process of Tilghman, yet this process is included in their operation and forms the basis of it. It is idle, therefore, to say that they do not infringe Tilghman's patent. It is unnecessary to determine what precise part the lime used by the defendants plays in their process—whether, as the complainant contends, it saponifies the fat to a certain extent, leaving the remainder to be acted upon by the water alone purely after the process of Tilghman, or whether, as the defendants contend, the lime produces a more perfect and active commixture of the fat and water or predisposes the fat to unite with the requisite elements of water necessary for producing glycerine and the fat acids. In either case the process of Tilghman, modified or unmodified by the supposed improvement, underlies the operation performed in the defendants' boilers.

Another ground assumed by the defendants to avoid the charge of infringement is that they do not heat the mixed mass in the manner pointed out in Tilghman's specification, but, instead of heating the containing vessel by an outside application of heat, they heat the contents by the introduction of superheated steam; but we think that this does not alter the essential character of the process. The heating by steam is clearly an equivalent method to that of heating by an external fire. The patent does not prescribe any particular method of applying the heat, except when using the pipe and coil apparatus described in the specification, and even in the use of this apparatus the outward application of the heat to the pipe is suggested incidentally and as a matter of convenience rather than as an essential requisite. The patentee showed one method in which the heat could be applied. That was all that was necessary for him to do. If it could be applied in any number of different methods it would not affect the validity of the patent as a patent for a process. The method of heating the mixture by the introduction of steam may be attended with some beneficial results in producing an agitation or automatic circulation helpful to the perfection of the admixture of the water and fat, and so far it may be an improvement on heating from without. Suppose this to be so, as before said, the introduction of an improvement gives no title to use the primary invention upon which the improvement is based.

Finally, the defendants argue that they only use a low degree of heat and pressure compared with that pointed out by the patent—namely, only about 310° Fahrenheit, instead of 612°. The precise degree of heat, as we have seen, is not of the essence of the patent. The specification only claims that a high degree of heat, such as would be sufficient to melt lead, is most effective and rapid in producing the desired result, but suggests a trial of the apparatus employed with different degrees of heat, so as to ascertain that which is best for each particular kind of fat. "By starting the apparatus," the language is, "at a low heat and gradually increasing it, the temperature-giving products most suitable to the intended application of the fatty body employed can easily be determined." It is probably true, as contended by the defendants, that by the use of a small portion of lime, the process can be performed with less heat than if none is used. It may be an improvement to use the lime for that purpose, but the process remains substantially the same. The patent cannot be evaded in that way. The matter may be stated thus: Tilghman discovers a process of decomposing fats by mixing them with water and heating the mixture to a high temperature under a pressure that prevents the formation of steam. It is a new process, never known before. The defendants, seeing the utility of the process and believing that they can use a method somewhat similar without infringing Tilghman's patent, put a little lime into the mixture, and find that it helps the operation, and that they do not have to use so high a degree of heat as would otherwise be necessary. Still the degree of heat required is very high—at least a hundred degrees above the boiling point—and a strong boiler or vessel is used in order to restrain the water from rising into steam. Can a balder case be conceived of an attempted evasion and a real infringement of a patent? And as to the low degree of heat used in the operations of the defendants, this must also be said: That, with the reduction of the temperature the time of perfecting the operation is more than proportionally increased. Tilghman was aware of this result and pointed it out in his patent. He expressly says:

"The decomposing action of the water becomes more powerful as the heat is increased."

What can be done in minutes by the application of a very high degree of heat requires hours to do at the temperature used by the defendants. But the process is still the same, and the defendants fail to evade the patent.

We pass by the fact that the defendants first took a license from the patentee, and under it and under his directions erected substantially the same apparatus, which they are yet using. Receiving what they regarded as additional light, they refused to continue the payment of a royalty and put the complainant to his legal remedy.

It is our opinion that the patent is for a process, that it is a valid patent, and that the defendants infringe it.

We have considered the case entirely upon its merits. It is unnecessary to bestow much discussion upon the technical objections that have been raised. They have not been pressed in the argument, and are probably not seriously relied on. One of them is, that no replication was filed in the case. To this it may be answered that the parties have throughout treated the case as though it were regularly at issue. The various stipulations into which they have entered with regard to the admission of evidence to be heard on the trial of the cause are totally inconsistent with the idea that the case was to be heard merely on bill and answer.

Another objection is that the patent was dated more than six months prior to the filing of the application for it; but under the law then in force (1854) with regard to the antedating of patents where a foreign patent had been obtained, this was admissible. The 6th section of the act of March 3, 1839, entitled "An act in addition to an act to promote the progress of the useful arts," expressly declared—

"That no person shall be debarred from receiving a patent for any invention or discovery . . . by reason of the same having been patented in a foreign country more than six months prior to his application: *Provided*, That the same shall not have been introduced into public and common use in the United States prior to the application for such patent: *And provided, also*, That in all cases every such patent shall be limited to the term of fourteen years from the date or publication of such foreign letters patent."

Now, we know by the proceedings on the application in this case that the attention of the Commissioner of Patents was expressly called to the fact of the issuing of the English patent, and that the question of the date of the patent in suit was submitted to and considered by him. Under the laws then in force he determined that the patent ought to be antedated as of the date of the English patent. It must be presumed that his decision was right according to the facts of the case, at least until the contrary is shown, and nothing has been shown to the contrary by any evidence in the cause to which our attention has been called.

The decree of the Circuit Court is reversed, and the cause remanded, with directions to enter a decree in conformity with this opinion.

OXIDATION OF BUILDING MATERIALS

NEARLY all our building materials suffer largely from the effects of oxidation, the chief causes of this destructive action being moisture accelerated by acids and contact. In the case of metals, it has been pointed out that humidity in the air and running water act by the formation of the hydrous oxide in proportion to the purity of the metal, and hence wrought iron is more rapidly affected than steel, and steel than cast iron. It is well known that cast iron has an outer skin, which is much less subject to rust, and, on this account, it is best suited for all exposed constructions, though, even in these situations, the metal should be protected or coated. Cast iron, cast in sand, is more readily oxidized than when it is cast in loam, especially when exposed to galvanic action, and this has been accounted for by the greater smoothness of surface of loam castings. When iron has to be galvanized the loam casting is decidedly preferable. It is needless to dwell on the importance of protecting wrought iron, and thin plates of it should never be exposed to the atmosphere without protection. Recent experiments have not yet furnished us with any ready and permanent preservative coating for iron, and coatings of zinc or asphalt appear to be the only resources which can be relied upon to arrest decay in iron exposed to moisture or sea water. Crystalline wrought iron is more subject to chemical action than the fibrous and amorphous kind of texture, and, according to Mr. G. R. Burnell, "the old Swedish iron and the charcoal iron, formerly used for iron railings in the metropolis, has yielded to the effects of the galvanic action of the atmosphere in a manner very different from the wrought iron made at present, which latter, being made from coal, is much more fibrous in texture."

It may be unnecessary to review the numerous patents and preservative processes that have been brought out and tried, and have been given up as inadequate to cope with the destructive action of the atmosphere upon ironwork. Good coatings of boiled oil are recommended for all malleable iron while it is hot, and for castings after they have been cleansed. Paints of oxides of lead and iron serve their purpose; but it would be dangerous to trust to their protection for any length of time, and, in the case of paints prepared from lead bases, a chemical action is set up between the surfaces; and we would rather be inclined to prefer the application of a coating of gas-tar or asphalt, known as Dr. Angus Smith's patent. Iron coated with this application is found to stand the atmosphere for a number of years longer than any other coating, and the mineral bitumen resists the action of acids and all iron exposed to fumes. Coating the iron with a preparation of pulverized glass, with bronze or copper, also of lead, have been tried with more or less success; but the difficulty is to apply such processes to large standing structures like bridges. Few of our readers have not heard the more recent treatment of iron on the Barff system, by which the articles are subjected to superheated steam at a very high temperature. We often wonder how long some of our iron railway bridges will stand the gradual deterioration and loss of substance they are being yearly subjected to. The steam from locomotive engines upon the iron roofs of many of our railway stations is another instance of rapid deterioration going on, and it may be worth the attention of our engineers to consider the expenditure necessary to keep such roofs in efficient order. The contact of lead and iron is well known to set up a chemical action destructive to ironwork embedded in stone, and the acid in oak is found to act injuriously on iron, as illustrated by the decay caused by iron nails in wooden ships. Much structural injury is due to the combination of iron and stone. The rusting of wrought-iron cramps is a common instance due to certain salts of lime, but old cramps and ties closely embedded in mortar, which excluded the air, have been found in a perfect state of preservation. We may recommend Portland cement as the most judicious fixing for iron in stonework.

The effects of oxidation on stonework are not less apparent in what is known as weathering, and there are but a very few stones—such as the very compact sandstones and the crystalline magnesian limestones—which are capable of resisting moisture. Of course, stones containing a large proportion of carbonate of lime must quickly suffer from oxidation, especially when exposed to alternate rains and frosts, to damp atmosphere and driving winds, and when their textures are more or less absorbent.—*Building News.*

EXAMINATION OF WINE.

By V. WARTHA.

1. DETECTION OF MAGENTA IN RED WINES.

IN all judicial cases the following should be applied in succession:

a. THE MAGNESIA TEST.—20 c.c. of the wine are mixed in a large test tube with excess of calcined magnesia. After well shaking there is added 1 c.c. of a mixture of equal parts colorless amylic alcohol and ether; the whole is well shaken and allowed to stand for some time. 1 mgrm. magenta in 1 liter wine may be detected by a rose coloration of the supernatant stratum. In strongly colored southern wines faint reactions are often masked by a yellowish or light brownish coloring matter.

b. THE SUGAR OF LEAD TEST.—20 c.c. of wine are mixed with 10 c.c. sub-acetate of lead of officinal strength, and the mixture after being well shaken is filtered into a perfectly dry test tube. If moderately large quantities of magenta are present they will be detected by the paler or deeper rose color of the filtrate. But even if it appears perfectly color less or yellowish, small quantities of magenta or aniline violet may be present. 1 c.c. of the above-mentioned mixture of amylic alcohol and ether is therefore added, the tube shaken up, and then allowed to stand for some time. If held against a white background very small quantities of magenta may be recognized in the upper stratum.

c. THE ETHER TEST.—If the sample has given strong reactions with *a* and *b*, concentration is not necessary. If the reactions were slight, from 150 to 200 c.c. of the wine are evaporated down to one-third to one-fifth of its original volume in a silver capsule, which should have been slightly ignited previously. The concentration is effected over an open flame as rapidly as possible, and the residue while still warm is poured into a stoppered glass cylinder, which should previously be washed with concentrated nitric acid and rinsed with pure water. The wine is mixed with an excess of pure ammonia, 30 to 40 c.c. pure ether are added, the cylinder is stoppered, and shaken carefully to prevent the formation of an emulsion. The clear ethereal stratum is then filtered through a clean dry filter into a perfectly clean porcelain capsule having glazed edges. One or two threads of clean knitting wool, 3 to 4 cm. long, which should have been previously washed and dried, are laid in the colorless ether, which is allowed to evaporate in a warm place. The wool takes a color which may vary, according to the proportion of the magenta, from a faint rose to a red. One of the threads is then reserved in a tube, while the other is cut in two, the one half moistened with hydrochloric acid, and the other with ammonia. In both these the red color should change to a yellowish. If aniline violet was present the threads will turn to a green. If the wine was pure, however deep in color, the wool remains white. Particular care must be taken that the ammonia employed contains no traces of organic coloring matters.

2. DETECTION OF SULPHUROUS ACID IN WINES.

About 50 c.c. of the sample are placed in a small distilling flask, the lateral exit-tube of which projects into a test tube cooled with moistened filter paper. The wine is kept at a gentle boil till 2 c.c. have distilled over. The test tube is taken off and a few drops of a neutral solution of silver nitrate are added. If even traces of sulphurous acid were present the liquid becomes opalescent or a white curdy precipitate of silver sulphite is formed, which is distinguished from silver chloride by its solubility in nitric acid. The distillate also reduces mercurous nitrate and decolorizes starch iodide and weak solution of potassium permanganate.—*Berichte der Deut. Chem. Gesellschaft zu Berlin*, No. 6, 1880.—*Chemical News.*

[Concluded from SUPPLEMENT No. 277, page 4421.]

ASCENT OF CHIMBORAZO AND COTOPAXI.*

By EDWARD WHYMPER.

THE wind was blowing at the rate of about fifty miles an hour from the northeast. We were getting wretched and hungry, without having the means to satisfy ourselves. With great trouble, a mercurial barometer was set up, one man grasped the tripod, another attempted to give it shelter by a poncho from the wind, and I, myself, lay on my stomach in the snow watching the descent of the mercury. It fell until it was 14·1, at a temperature of 14° Fahr., which, when compared with an observation made on the same day at Guayaquil, gives for the height of Chimborazo 20,540 feet. By the time the barometer was in its case again it was twenty minutes past 5 o'clock, and there was scarcely an hour and a quarter of daylight remaining. We fled across the plateau at the highest possible rate. There is, as you are aware, a great difference between descending and ascending soft snow, and, as we had a huge trough or groove already made, we moved down it with comparative facility. Still, it took nearly an hour to extricate ourselves from that plateau; we then ran for our lives, for our arrival at the camp that night depended on our being able to cross those rocks before darkness fairly set in. We just succeeded in arriving at them in time, although it became pitch dark before we crossed them; then we saw our camp fire, and heard the disconsolate shouts of Perrin, who was left behind, as we came hurrying down, and we arrived there soon after 9 P.M., having been out nearly sixteen hours on foot the whole time.

The hurried way in which we left the summit made me desirous of ascending again, but I found that Louis Carrel was *hors de combat* from having his foot frost-bitten. As soon as it could be done he was sent down to the nearest place where he could receive attention, and I remained myself up two days longer at the second camp. On the 12th of January I rejoined them, and we then moved by easy stages down to the Machachi. We waited there for nearly four weeks before we could take the field again. The poor man suffered very severely, but it is due to you to say that it was through his own fault. On leaving the tent for the ascent I remarked he was not wearing gaiters, but he said he was accustomed to go without. Jean Antoine used gaiters of the usual type, and I used a pair which, from having the leather continued all around, are well nigh impervious to water. In wading through the snow of the summit it was wet as well as soft, and Louis Carrel got his feet badly wetted, and afterward they froze, whereas Jean Antoine and I returned to the camp quite untouched.

My residence on Chimborazo thus extended over seventeen days; one night was passed at a height of 13,400 feet, ten at a height of 16,500 feet, six at 17,300 feet. During this time, besides the ascent to the summit, I also went three times as high as 18,300. When we quitted the mountain all trace of mountain sickness had disappeared; nor did it touch us again until we arrived at the summit of Cotopaxi.

This is a convenient point, before passing on to Cotopaxi, to say a few words respecting the country and the people of the country, their manners and customs. The road to Quito, I have already said, goes over the southern side of Chimborazo. It then passes around the eastern side of Chimborazo, and then goes further down to Arenal, and so to Quito. As far as the house, called Chuguipoquio, is, for the most part, only a rough mountain track, but here again you come to a made road, which continues without intermission to Quito. This is the only made road in the whole interior, and it is a busy one, with plenty of life passing along it. In December, 1879, I reckon we met or passed not less than 1,300 beasts and 500 persons every day. A newly-arrived European is somewhat astonished that, with this large traffic, the track should be left in such a villainous condition, but, after having been over the other so-called roads in the interior, his surprise disappears, and he begins to regard the Quito track as something very superior indeed. I am bound to say I did not on any part of it see mud more than two feet deep, whereas in other roads we had mud three and four feet deep. Even this is considered a very small amount, and an old resident in Ecuador once rebuked me for calling a road bad in which our beasts had sunk half way up their flanks. On asking him what he called a bad road, he said: "A road is bad in which the beasts tumble into mud holes and vanish quite out of sight." On the Quito road you meet with a great diversity of character. A large portion of the population, probably one-half, is composed of pure Indians, who were found by the first Spanish conquerors. The remainder of the population consists of people of a mixed race. It is universally admitted that there are very many Indians of perfectly pure descent whose families have never been tainted by alliance with whites, but it does not appear to be possible to find a single Spanish or other European family which has not contracted alliances with the Indians. We had many dealings with the Indians, and found them, on the whole, to be honest, truthful, and well-disposed. They are certainly, for the most part, hardy, industrious, and tolerably intelligent. They are also sober. We saw extremely little drunkenness among them, except in the province to the north of Quito, where they are very numerous and prosperous. The small number of intoxicated persons seen throughout Ecuador is remarkable, and I was inclined to regard the whites as a very sober race, until I learned that it was the habit of the country when any one wished to get drunk to go to bed and get quietly drunk in bed. This is a very interesting custom, and might be advantageous to introduce it among ourselves, until drunkenness is abolished altogether. The greater part of the persons mentioned on the road are naturally those concerned in the traffic between Guayaquil and Quito and other towns in the interior. Traveling for the sake of seeing the country is, of course, unknown; but occasionally you meet with some one a little out of the common who is traveling to pay a visit to some neighboring farm; and such a person is generally worthy of inspection. If he is got up correctly he will be wearing his so called Panama hat, a straw hat which will roll up, and costs any sum, from about 10s. to £10. To take care of this precious article, he puts on a white outer casing, and, as this would get spoilt by the rain, he puts an oil-skin cover on the top of that, so that he has three hats on, one over the other. To protect his eyes, he ought to be wearing a pair of blue goggles, which are sold in Birmingham at half a crown a dozen, and in Quito at half a crown apiece. Outside he will probably have on a poncho of superior quality, such as this, and underneath it a coarser one. What he may wear in the guise of trowsers I cannot say, because they are covered with buskins made of the skin of some wild animal. His feet are very nearly invisible, and, if you see them, you will most likely notice his toes peeping through his shoes, but, for the deficiency thereabouts, he makes up in the heel by his spurs. Here is a specimen of these articles, but this is considered a moderate thing in spurs; I can assure you many are worn more than double the size. Altogether, he is what we should call a regular guy. But we have not yet done with him. If he is properly turned out, he carries at his button-hole a drinking cup, which may be carved and silver mounted; at his side a tremendous chopping knife, which is used either for cutting away branches or as a toothpick. If he is a person of great distinction, he will be strong in his whip, which will have a wrought-iron handle, as it is found that one of that description does not break so readily on the heads of mules as wooden ones. He will also carry a guitar at his saddle. Such a person, according to the phrase of the country, is a great cavalier, and, if only decently mounted, he may aspire to marry any woman in the land. It is needless to say that, in roads in the state I have described, there are many accidents to baggage animals; beasts get stuck, their loads are thrown off, and sometimes abandoned, but what causes, I believe, far more loss, is the pilfering which takes place, and which it is almost impossible to prevent. I have been offered bottles of brandy by persons on the road, who, I am quite certain, could not have come honestly by them, and I have seen wine cases taken off a mule, taken indoors, opened, a bottle or so taken out, the case fastened up again, and loaded. To illustrate this I may tell you a case which was related to me on a visit to a fraternity of Jesuits. One of them said to me, "Señor, you know that the wine of this country is both dear and bad, and we thought that if we imported it ourselves, direct from France, we might get a pure wine at a moderate price; and so we ordered, as an experiment, a cask from a French house, but it cost us very dear. When it arrived we were glad to find that it was full, and that it did not leak; but I am sorry—oh, I am sorry to tell you that, when we opened it, we found that it was full of very dirty water." These accidents and the weight of the heavy duties which are imposed are, no doubt, the main cause of the high price of foreign goods at Quito and in the interior generally. An ordinary quart bottle of "Bass" costs 4s., and a pound of English salt 3s. 4d., while a common iron bedstead that would be dear in London at 50s., I have seen marked at £9. Accidents notwithstanding, these prices appear to leave a good margin for profit, and an enterprising man could probably make 100 per cent. on his transactions. You must remember, however, to take into account an unknown quantity of earthquakes and revolutions. You may be a rich man one day and a bankrupt the next. Trade in these regions may be said to possess all the excitement of gambling without its immorality; but it does not appear to be very fascinating to the English, for, at the time of my visit, I found only two of my countrymen in Quito. In touching on morals I tread on delicate ground, because, what the Ecuadorians consider moral, we should term immoral. I shall, however, relate one instance, which conveys a vivid idea of the manners and customs of the country. Some years ago the late Archbishop of Quito, who was a much-respected man, moved to indignation by the immorality of some of his flock, tendered a reproof; but some sons of Belial, in revenge, stole into the vestry on the occasion of an important church festival, and put strychnine into the sacramental wine. The archbishop partook of it, and fell dead before his people. This incident created so great a sensation that the authorities forgot to punish the assassins, who are still at large, and—perhaps to prevent a repetition of such things in future—they suppressed the archbishopric and seized a great part of the revenue. You have here developed in this single instance a gross, immoral and atrocious crime which is left unpunished, and a flagrant disregard of vested rights. As this is the description of the people themselves throughout Ecuador, you will see good reason for the non-interference of a stranger in their politics. I studiously avoided meddling with their concerns; still, it was not possible to be any length of time in the country without hearing a good deal about its domestic affairs, and in some respects these are both interesting and edifying. The Parliament, or House of Assembly, it is said, comes together only on rare occasions, and when it meets it manages to do without all-night sittings, and its members obey the ruling of their president, and vote exactly as they are wanted. It might be worth while for her Majesty's Government for the time being to send a special commissioner to Ecuador to learn how this desirable state of affairs can be arrived at. Then with respect to finances, they manage extremely well. There is no augmentation of the public debt, for the simple reason that no foreign country will lend them money, and the inhabitants are far too wise to lend it to each other. This universal distrust arises from the undeviating habit of repudiating contracts. No bargain ever seems terminated, and, in respect to this matter, one of the most respectable and honorable of foreigners of Quito told me that he never considered a transaction completed until he had given his customer a whipping. The marks of the whip, it seems, answer the place of a receipt stamp. The Ecuadorians are, as I have said, a very interesting people, and there is much that is curious and amusing in their manners and customs, but it is most pleasant to study these at a distance.

In passing from Chimborazo to Cotopaxi we go from an extinct volcano to an active one, and to one of the most terrible volcanoes in the world. It is situated, roughly, northeast from Chimborazo, at a distance of sixty-five miles. From Quito it bears southeast about thirty-three miles. Three years ago, during the last eruption, ashes from it fell in Quito to such an extent that it was pitch dark at mid-day, and persons in the streets in front of their houses could not tell where they were. On this occasion, too, there was a great manifestation of flames, which rose to an enormous height; the lava rapidly liquefied and poured down in vast torrents, which caused rivers six miles distant to rise sixty feet above their ordinary height, and in one instance, I was informed, it carried away a bridge one hundred feet above the stream in the village of Antisana, where a cotton factory was established some twenty-five miles from the mountain; the whole place was razed, and the heavy machinery was carried thirty miles down the river. All round the mountain the natives have stories of the tremendous ravages which occasionally occur. The general opinion seems to be that the periods of greatest activity are always preceded by periods of repose. In fact, it is said of the mountain, as it is of children, when it is quiet it is sure to be in mischief. During my enforced stay, through illness last March, I was in the immediate neighborhood of this mountain, and had abundant opportunities of studying its behavior. It was unusually tranquil, and although fretting and fuming and giving occasional growls, conducted itself, on the whole, in a quiet, well-behaved manner. I several times remarked that during the night much less smoke or vapor came away from the crater than during the day, and this led me to conclude that, if we could pass a night on the summit, we should be able to see the bottom of the crater, a sight no one had hitherto enjoyed. So far as one could judge by examination with the telescope, it did not appear that we should be able to find a reasonably protected place on the all but naked final cone; so, in addition to the troubles which were likely to occur from living at a great altitude, we had the chance of being blown up by the mountain, or being blown away by the wind.

All our arrangements were carefully matured, and we started for Pichincha, passing at first through a small hamlet, then turning south, and then up a ridge of the mountain, which descends toward the west, and encamped at a height of about 15,000 feet. As the transport of our camp equipage, all through, was beyond the power of the Carrels, I called for volunteers from among the natives, and those who came we now proceeded to dress up in accordance with our own views of propriety. The native dress is as unsuited to mountaineering as it can well be; commencing with a straw hat, which always blows away; then a long poncho, a variety of blanket, with a slit in the middle, through which the head is passed, and this is sure to fly up in your face at a critical moment; then rough shoes, which, although not unsuited to ordinary use, are totally inadequate to snow or rock work. The rest of their attire is of the most flimsy description. I am speaking now, of course, of the inhabitants of the interior, living at a height of 8,000 or 10,000 feet, at which there is an almost invariable temperature of 50° or 60°. In the lower country much less dress is worn, and they seem to have attained in some cases the perfection of simplicity. I hold in my hand the entire dress of a native of St. Miguel-del-Colorado. This is a fit dress either for a garden party or an evening assembly, and as there appears to be some connection between unscantiness of attire and perfect bliss, you may fancy yourself when there, if not in Paradise, at least not far from the Garden of Eden.

On the 16th we sent up the first installment of our stores to the final cone. The weather was very bad, with a varying temperature, and I did not go up till the 18th. The view from our camp extended over a large expanse of country, cut up by cracks and fissures, in every direction covered with cinders and blocks of lava. It seemed curious that although the cone, for at least six or seven miles in all directions, was covered with lumps of scoriæ, which, from the manner in which it was dotted about, appeared to be ejected from the crater, I could not learn that an ebullition of any considerable volume had ever been witnessed on the part of the natives. Some ridiculed the idea that they had ever been thrown out; yet in respect of fire, water, and ashes, every one had something to say. They generally agreed in stating that flames were frequently seen to rise above the rim of the crater, and that even when the lava is not flowing, and ashes are not being ejected.

On the morning of the 18th we started before daybreak, and at half-past six arrived at the edge of the crater. We had so far improved in condition that, when between 18,000 and 19,000 feet, we made three hundred and sixty steps without stopping, and only halted then because our men were tired. The ascent cannot be said to present any difficulties; we passed almost the whole way over snow up to the final cone, and then over ash mixed with ice. This final cone is the steepest part of the ascent, and on our side presented an almost continuous angle of 36°.

We advanced, and from a few feet of the edge we had to peer into the unknown. A vast quantity of smoke and vapor was boiling up, and we only saw at intervals a portion of the opposite side, the bottom being invisible. We then returned to make a place for the tent, with the assistance of the natives. When this was done we sent them back to the first camp, and the Carrels and I remained alone. The camp was necessarily established on the outside of the final cone, which at this time was entirely composed of ash. This was very warm to the touch, and so loose as to render it a matter of much trouble to fix the tent ropes, and a high wind springing up, we carried out four additional ropes, and attached them to the largest stones we could find, and buried in the ashes. We then rigged up a rope, as a sort of hand-rail, from the tent immediately to the edge of the crater, from which it was distant about 250 feet. We had scarcely completed the operation, when a violent storm arose, which threatened to carry our whole establishment away. The poles of the tent quivered, the ropes dragged, and it was a question whether the tent would weather the squall. But the storm passed away as suddenly as it arose, and for the rest of our stay we were not much troubled by the wind. While this was going on we had another cause for alarm. A great smell of India-rubber commenced to arise, and, putting my hand to the floor of the tent, I found it was on the point of melting, and, placing a maximum thermometer on the floor, it rose to 110°. As my feet did not feel at all warm, I tried in another place, and found on the other side of the tent it was 50° and in the middle 72°, while outside it was intensely cold, and in the night a minimum of 13° was shown in the temperature.

At intervals of about half an hour the crater regularly blew off steam; no stones were observed. The steam appeared to be very pure; it rose in a jet of great violence from the bottom of the crater and boiled over the edge, continually enveloping us. The noise made on these occasions resembled that which we hear when a large steamer is blowing off steam. We sustained scarcely any inconvenience from it, and this was the more remarkable since we had been well nigh stifled with sulphurous vapor about 1,500 feet from the edge of the crater when coming up. When night had fairly set in we went up to view the interior, and saw the whole of its vast proportion for the first time. By measurements made on the following morning I find that the rim has a diameter from north to south of 200 feet, and from east to west of about 1,500. The rim is irregular, some points being considerably higher than others. The rock is trap; in the interior the walls descend to the bottom in a series of steps, and a precipitous slope of about 1,000 feet. At the bottom there was a nearly circular spot of glowing fire 24 feet in diameter. In looking at this it was impossible to say whether liquid lava filled the pipe up to its orifice or not. Flames were flickering and traveling about in all directions, so that what was underneath them appeared more like incandescent than molten matter. The heat at the bottom of the crater was evidently intense, and far up its sides, in every direction, glowing fissures, from which flickering flames were also coming, showed that lava was red hot below the surface, while columns of steam or smoke, rising from hidden orifices, heightened the effect. It is impossible to conceive a more dramatic spectacle than this vast theater represented, illuminated below by the subterranean fires and above by a brilliant moon, while every now and then these outbursts of steam occurred, rushing upward with the force of a hurricane, and scattering all around fragments of fused rock. Then—although I had said the steam appeared to be pure—

* A recent lecture before the Society of Arts, London.

we found in the morning the tent was black with ash which had been ejected. Had we remained on the summit only a short time this would not have been noticed. The fragments were found, on microscopical examinatfon, to be particles of fused rock, and they are, I think, torn off by the violence of the steam blasts. This will be found to be of interest in connection with what you will hear subsequently. I attribute these outbursts to the infiltration of the snow and hail which falls on the final cone. It is almost immediately liquefied, and descends into the bowels of the mountain. We noticed while on the mountain that the whole upper part of the cave was white with snow or hail, and yet in the course of an hour or two it would entirely disappear and descend into the mountain. On one occasion, while on the summit, it hailed so violently as to cover us with an inch of ice, and yet in half an hour this entirely disappeared.

The height of Cotopaxi is 19,600 feet. Our camp was placed about 130 feet below the loftiest point, and was the most elevated position at which any of us had ever lived. We remained there twenty-six consecutive hours, feeling slightly at first the effects of the low pressure, having the same symptoms as we noticed on Chimborazo; and we used chlorate of potash, and remarked its good effects. All the signs of mountain sickness had passed away before we commenced the descent, and they did not recur again during the journey. Nearly five months later we found ourselves again on Chimborazo. I desired to make a second ascent for several reasons, but principally because our stay on the summit on the first occasion was too brief to permit us to accomplish our work. Besides, the observations of the barometer were somewhat hurried, and I did not feel sure that the deduced heat established a good determination. If, however, a second reading should accord with the first, it would, besides confirming it, establish confidence in respect of observations made in the meanwhile on other mountains. We were too much laden on the first occasion, but now we had trained two natives into respectable mountaineers in order that they might support us. After ascending a peak we crossed a depression between two mountains and encamped in a charming spot, surrounded by butterflies and humming-birds. Next day we mounted up to camp five, which was almost 15,000 feet above the others. My time had nearly expired, and we were delighted by a stroke of good fortune. Next morning was clear and even cloudless, and we saw long before dawn our old friend Cotopaxi in the far distance, and remarked how tranquil it looked—not a sign of smoke was rising from the great volcano. We went on foot, and, before daylight, soon commenced to ascend the ridge which leads continuously toward the second summit. I was in the rear, stopping to heat my numbed hands, and looking toward Cotopaxi, when all at once I saw a column of smoke commence to rise from the crater. It went up straight into the air, rapidly curling with such velocity that within a minute it had risen 20 000 feet above the crater. It was caught by an easterly wind and borne twenty miles toward the east, at right angles toward its former course; it then turned, and a northerly wind carried it toward our position. As the cloud came nearer and nearer to us it appeared to rise higher and higher in the sky, and about twelve, at noon, it got overhead and shut out the sun. But before this happened we witnessed the most extraordinary and startling effects in the atmosphere between us and the volcano—a thick cloud, sometimes like shining brass, then turned to tarnished copper, or the most extraordinary green, producing a feeling of intense astonishment, which could not be banished. In the curled openings in the clouds that arose after the commencement of the eruption I still saw a majestic column of ash pouring out and rising to an immense height in the air, blacker than the deepest ink. As we were engaged in the ascent of Chimborazo, and had many other things to occupy our attention, we did not appreciate at first the magnitude of the eruption, but when we got on the summit and found the ash beginning to fall to such an extent that the snow looked like a plowed field, we perceived something out of the common was happening. We arrived on the summit at twenty minutes past one on this occasion, and had the satisfaction of finding the end of a flagstaff, which had been put up on the first occasion, still appearing above the snow. You will readily believe that I referred to the barometer with no little eagerness, and this time it read 14·28 in an air temperature of 15° Fahr., which gave for the height of Chimborazo 20,489 feet, or 56 feet less than on the first occasion, the mean of the two deductions being 20,517.

When we returned to our tent on the 5th of October we found it laden with ash from Cotopaxi. It was still falling, and covered the country all round as with a dense fog. I collected more than three ounces from the tent, but this was not half that which was upon it, and much more slipped off down the sloping sides. I subsequently found in the town of Ambato, twenty miles nearer the mountain, between 11 o'clock and 11:15, upon a piece of paper spread to receive it, one foot square, four ounces were collected, and from these data I have made a calculation that the minimum quantity which must have been ejected, drawing two lines from Cotopaxi, one leading to Riobamba, twenty miles to the east of our station, and another on a line as far to the west, within which limits I am certain this ash was falling, at least 2,000,000 tons of this ash must have been ejected during this eruption. The quantity is under-estimated in a variety of ways. The ash was carried beyond the limits indicated, and I believe it fell over many hundred square miles further. The quantity taken into account was that actually found on the tent, but from Ambato, northward, that quantity only is reckoned to fall in a quarter of an hour. Professor Bonney has recently submitted this to microscopical examination, and, estimating the size of the particles, we find the ash which fell on our tent at the summit of Cotopaxi was so exceedingly fine that 4,000 particles scarcely weigh a grain. That which fell upon it when on Chimborazo was much finer, and, in estimating that 25,000 particles go to a grain, we are well within the mark. They bear a strong family resemblance to one another, and consist principally of glassy feldspar and of long crystalline scoreous dust. It is certain that that which fell on us on the summit was torn off by the steam blasts to which allusion has been made, and I conclude that the matter which was ejected during the other eruption was torn off and thrown out by a continuous blast of almost inconceivable violence.

If you can picture to yourselves the force which is required to eject 2,000,000 tons of this ash (so light that 25,000 particles scarcely weigh a grain) to a height of four miles in the air upward from the crater, and to send it up vertically, unaffected by the east wind, you may be able to form some idea what a terrible creature Cotopaxi is in his more furious moments.

This, ladies and gentlemen, brings my remarks to a close, and, in conclusion, permit me to say a word more in respect to mountain exploration in general. Among certain persons it is still fashionable to affect a description of scorn, bordering on contempt, for anything in connection with mountains and mountain work. None of us feel, perhaps, very deeply the criticism of those who are individually ignorant of the subjects on which they talk, and for this matter, speaking for myself, I rather look forward to the time, which will surely come, when the study of mountains, the ascent of mountains, and even prolonged residence on mountains, will be found essential for the prosecution of a score of sciences. Before this could be carried out it was necessary to learn whether life could be made endurable at great heights. We were always haunted by the fear of an invisible enemy who might strike us down at any moment. What we wanted to know was, not whether life could exist at a height of 20,000 feet; that was settled seventy-five years ago by Gay Lussac; but whether man could become so far habituated to the low pressure which is experienced at that height as to be able to live without inconvenience and to do useful work. I went to the Andes in search of the answer to this question, and, having heard the story, you can form an opinion whether it affords an encouragement for the prosecution of exploration in other quarters. There is, I think, no department of travel more fascinating than mountaineering. Mountains present the grandest natural features; they will be always equally attractive near or far, in cloud or in sunshine; their wonderful variety of outline, their startling contrasts of color, and their dazzling effects have ever been sources of inspiration for poets and for painters. They afford perpetual instruction to the geologists, and they will, no doubt, one day throw a light on those great questions touching the origin and distribution of species which have so much exercised the ingenuity of botanists and zoologists during recent years. Mountains affect climate, give birth to rivers, have fixed the boundaries to kingdoms, and have determined the limits of races; they have often wrecked the ambition of the invader, or sustained the hopes of the patriot; they form some of the best material guarantees for the peace of the world. So far from being inclined to take a low view of the usefulness of mountaineering, I hold that the study and the exploration of mountains is of the first importance for the purposes of political and physical geology.

THE PEASANT POPULATION OF SERVIA.

THE population of Servia is about 1,750,000, of whom nine-tenths are peasants, living entirely from agriculture; 60 per cent. of the Servian villages range from 50 to 500 inhabitants per village, and 25 per cent. range from 500 to 1,000 per village. It follows, therefore, that the peasant population is very much scattered, though in the valleys villages are not widely distant from each other, and it may be divided into two schools, the old and the new. The peasant of the old school lives and cultivates his land in the most primitive manner possible, while the peasant of the new school is (as a result of the national system of education, under which a school is now to be found in every considerable village) more advanced on the path of civilization.

The peasant of the old school lives in a cottage with mud floors and mud walls; his live stock consists of a yoke of oxen, half a dozen pigs, and a small flock of sheep and goats; his plant comprises a wooden plow, costing about one ducat (10s. sterling); a wagon built entirely of wood (not a particle of iron entering into the construction of either wagon or wheels), which cost about three ducats, or 30s.; a sekira (an ax weighing about 10 lb.), with which he executes the repairs required for the house or the plant; half-a-dozen hoes for the maize and the vineyard, and half-a-dozen pruning hooks for the vines; several large barrels for wine and rakija, and a few large earthenware vessels, for his goats' and sheep's milk. The oxen draw the plow, and he himself guides it, but almost all the rest of the field work is done by his wife and daughters. The thrashing of the corn is achieved thus: A piece of ground about 40 feet in diameter is well trodden down, and a large stake is driven in the middle; a pony is borrowed or hired from a neighboring carrier, and is attached by a long cord to the stake, the corn in the straw is spread over the ground, and the pony is driven round and round till he has wound the cord round the post, he is then driven in the opposite direction till he has unwound and rewound the cord, and this is repeated till the corn is more or less thrashed out of the straw. The winnowing is very simple and very imperfect, it being done by the wind. The peasant with a wooden shovel throws the corn high up into the air against the wind, which is supposed to carry away the chaff.

The clothing of the peasant of the old school is, with the exception of his fez, nearly all home-made; his wife and daughters spin and weave the cloth of which his shirt, his coat, his "tchaksheri" (broad pantaloons), and his stockings are made. His "opantzi" (sandals) are often made by himself, and his winter coat and cap are generally of sheepskins from his own flock.

But the peasant of the old school is rapidly being superseded by the modern Servian peasant, who dates back from the year 1832, when Prince Milosh founded at Kragujewatz, the first Servian gymnasium, which was followed in 1843 by a General Education Act, under which, and subsequent acts, education became general and free, no fees of any kind being payable by the pupils. This might, at first sight, appear to have very little connection with agriculture, but education has exercised a very material influence on the Servian peasant; it has improved his mode of life and his method of cultivation, so that he produces more and spends more, thus contributing more to the exports, and raising the imports of the country. The peasant of the new school builds his house of stone or brick, and furnishes it with a view to comfort, if not to luxury; his land is farmed, too, with some regard to scientific principles, his plow is of modern construction, often entirely of iron and steel. His favorite plow is of wood and iron, for 12-inch plowing, weighing, with the fore carriage, about 130 lb., and costing at Pesth about five ducats, or £2 10s., but, on account of the difficulty of transport, there being a total absence of railway communication, only 400 to 500 plows are imported annually into Servia, and these are to be found chiefly in the vicinity of the Danube. The modern school of peasants understands, too, the advantage of thrashing by machinery, and a hand-thrashing machine, of iron and wood, weighing about 450 lb., and costing about 25 ducats, or £12 10s., at Pesth, is not unfrequently to be found among his plant, as also a hand winnowing machine, weighing about 300 lb., and costing about ten ducats, or £5, and a maize-rasping machine, for separating the maize grains from the stalk, weighing about 200 lb., and costing about ten ducats, or £5. But the interior transport difficulty restricts the import of these machines in common with that of all heavy goods. The modern school of peasants, although clinging to the national costume, with regard to pattern and fashion, is rapidly adopting Western woolen and cotton manufactures as the materials for his clothing, and that of his wife and family, and this fact cannot fail to have a large and increasing influence on the import of woolen and cotton textile manufactures into Servia.

JUPITERIAN OBSERVATIONS.

FROM seven years' observation of the surface of Jupiter, Herr Bredichin concludes that the inequalities in the angular velocity of the different figures seen on the planet may possibly be explained by assuming (1) that in the neighborhood of the equator there is a solid, elevated zone, which, however, does not rise beyond the limits of the atmosphere, and (2) that the crust of the southern hemisphere transmits more internal heat into the atmosphere than that of the northern, and this affects the direction of currents of gases and vapors passing from one hemisphere to the other. The phenomena observed in that part of the crust which appears through the vaporous layer as a red spot prove, he says, the considerably deeper position of this spot as compared with the equatorial zone, and the preponderating heat development on the southern part of Jupiter. Herr Bredichin gives the distances of the southern and northern borders of the elevated equatorial zone from the equator, for the years 1874 to 1880, and he finds that the equatorial zone must be steeper to the south, while it has a more gentle fall to the north, so that here it is varying, and covered more or less with clouds and vapors. The highest strip of this zone seems to be 2° from the equator, on the north.

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